



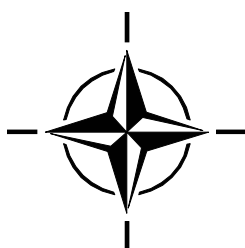
RTO TECHNICAL REPORT

TR-MSG-019

Verification, Validation, and Accreditation (VV&A) of Federations

(Vérification, validation et accréditation
(VV&A) des fédérations)

Final Report of Modelling and Simulation
Group 019 / Task Group 016.



Published April 2008





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RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote co-operative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective co-ordination with other NATO bodies involved in R&T activities.

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- NMSG NATO Modelling and Simulation Group
- SAS System Analysis and Studies Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

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Published April 2008

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ISBN 978-92-837-0088-3

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Acknowledgements

NATO MSG-019 would like to acknowledge the significant contributions made by the following members of the Simulation Interoperability Standards Organization (SISO) VV&A Overlay Product Development Group (PDG) drafting committee who were not officially part of the NATO MSG-019 Programme Committee:

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Verification, Validation, and Accreditation (VV&A) of Federations (RTO-TR-MSG-019)

Executive Summary

When MSG-019/TG-016 was established, both the NATO and the distributed simulation communities had realized a need for guidance about the Verification, Validation, and Accreditation (VV&A) of federations. The efforts of this Task Group addressed this need for both communities by developing a baseline view of VV&A which emphasized the lack of a universal model for federation VV&A processes due to divergent national perspectives and needs. The Task Group determined that the lack of consistent methodology was hampering NATO's ability to develop shared simulation federations. Resolving these disparities required developing a consistent understanding of what VV&A is and how to apply it to achieve the best results. Despite member nation's different perspectives, they were able to agree on a single unified model of federation VV&A processes. Thus, the baseline and the results from the Combined Convention on International VV&A Standardization Endeavours (CConVV&A) resulted in a decision to merge the efforts of this Task Group and the Simulation Interoperability Standards Organization (SISO) VV&A Overlay drafting group. This merge expanded the focus of this Task Group beyond preparing a technical report to actually producing a VV&A Overlay standard product. The Task Group also identified several terms needed to describe VV&A processes for federations and developed definitions for these terms using existing standard definitions.

Formalizing the Overlay as an Institute of Electrical and Electronics Engineers (IEEE) standard was determined to be the most appropriate standardization approach as it provides international recognition and access; co-locates the Overlay with its companion document IEEE standard 1516.3 for the High Level Architecture (HLA) Federation Development and Execution Process (FEDEP); and provides maintenance and management of the Overlay by IEEE. The proposed IEEE standard (1516.4) addresses the needs of both the NATO and SISO communities for a VV&A Overlay to the FEDEP. This Task Group succeeded through extensive collaboration with other international groups including SISO, Western European Armament Group Research and Technology program on VV&A (REVVA) and International Test Operations Procedures (ITOP). The tight coupling between the NATO and SISO groups resulted in a better, more widely applicable Overlay (e.g., government, industry, and academia). The collaboration benefited NATO by directly coupling the Modelling & Simulation Group (MSG) product to an internationally recognized standards body and benefited SISO by ensuring early and extensive international input to the final product. This collaborative effort could serve as a model for future joint Modelling & Simulation (M&S) standards initiatives.

While the Task Group feels that enormous strides have been made with the development of the VV&A Overlay, still more work is needed to increase the effectiveness and efficiency of the VV&A processes. Particular areas to be addressed include case studies to mature the Overlay, tailoring the VV&A processes based on user risk management, and effective communication of risk to program management.

Based on the above conclusions, the Task Group makes the following recommendations:

- 1) NATO should adopt Appendix 1 as an interim Standardization Agreement (STANAG) until the IEEE 1516.4 standard is issued and then revise the STANAG to adopt the IEEE standard.
- 2) MSG-054, the follow-on study group, should participate in the IEEE 1516.4 balloting process, monitor on-going VV&A case study initiative and incorporate suggested improvements to the

Overlay during the balloting process, and study the relationship between user risk, acceptance criteria, and tailoring of the VV&A process.

- 3) NATO should consider adopting similar collaborative relationships with international standards bodies as appropriate.

Vérification, validation et accréditation (VV&A) des fédérations (RTO-TR-MSG-019)

Synthèse

Lorsque le MSG-019/TG-016 fut mis en place, l'OTAN comme les communautés de simulation distribuée se sont rendues compte de la nécessité d'un guide pour la Vérification, la Validation et l'Accréditation (VV&A) des fédérations. Les efforts de ce groupe de recherche ont fait part de ce besoin aux deux communautés en développant une vision de référence sur la VV&A qui mettait en relief le manque de modèle universel pour la Vérification, la Validation et l'Accréditation des fédérations à cause des perspectives et besoins nationaux divergents. Le groupe de recherche a déterminé que le manque de méthodologie cohérente diminuait la faculté de l'OTAN à développer des fédérations partagées de simulation. Résoudre ces disparités nécessitait de développer une compréhension cohérente de ce qu'est la VV&A et comment l'appliquer pour obtenir les meilleurs résultats. En dépit des perspectives différentes des nations membres, elles purent s'accorder sur un modèle unifié à propos de la VV&A des fédérations. Ainsi, la référence et les résultats de la convention combinée sur les efforts de normalisation de la VV&A internationale (CConVV&A) aboutirent à une décision de fusionner les efforts de ce groupe de recherche et du groupe préparatoire de l'organisation des normes d'interopérabilité de la simulation (SISO) VV&A Overlay. Cette fusion étendit le champ de ce groupe de travail au-delà de la préparation d'un rapport technique pour effectivement produire une norme VV&A Overlay. Ce groupe de travail a aussi identifié plusieurs termes nécessaires pour définir la VV&A pour les fédérations et a mis au point une définition de ces termes en utilisant des définitions standard existantes.

On a déterminé que formaliser cette Overlay sous la forme d'une norme IEEE (institut des ingénieurs électriciens et électroniciens) était l'approche normative la plus appropriée, car cela permet de disposer d'une reconnaissance et d'un accès international ; cela permet de rapprocher l'Overlay des documents voisins IEEE, à savoir : Standard 1516.3 for the High Level Architecture (HLA) Federation Development and Execution Process (FEDEP) ; cela permet aussi d'entretenir et de gérer l'Overlay selon la norme IEEE. La norme proposée IEEE (1546.4) résout à la fois les besoins de l'OTAN et ceux des communautés SISO pour l'Overlay VV&A par rapport au FEDEP. Ce groupe de recherche a réussi grâce à une collaboration extensive avec d'autres groupes internationaux comprenant SISO, Western European Armament Group Research et Technology program on VV&A (REVVA) et International Test Operations Procedures (ITOP). Cette étroite coopération entre les groupes OTAN et SISO a abouti à une meilleure Overlay (administration, industrie et universités) plus généralement applicable. Cette collaboration a profité à l'OTAN en couplant directement le produit MSG (groupe de modélisation & simulation) à un organisme normatif reconnu internationalement, et au SISO en lui donnant un accès précoce et international au produit final. Cet effort de collaboration pourrait servir de modèle à des initiatives interarmées de normalisation en matière de modélisation et de simulation (M&S).

Tandis que le groupe de recherche a le sentiment que des pas de géant ont été faits pour développer la VV&A Overlay, il n'en demeure pas moins que du travail supplémentaire est nécessaire pour augmenter l'efficacité des processus VV&A. Les domaines particuliers dont il faut s'occuper incluent des études de cas pour faire mûrir l'Overlay en « taillant sur mesure » les processus VV&A d'après la gestion des risques par l'utilisateur et la communication effective du risque sur la gestion du programme.

Compte tenu des conclusions ci-dessus, le groupe de recherche fait les recommandations suivantes :

- 1) L'OTAN devrait adopter l'Appendice 1 comme accord temporaire de normalisation (STANAG) jusqu'à ce que la norme IEEE 1516.4 soit publiée, puis réviser le STANAG pour adopter la norme IEEE.
- 2) Le MSG-054, groupe de suivi d'étude, devrait participer au vote sur le 1516.4 de l'IEEE, surveiller l'initiative d'étude du cas VV&A et incorporer les améliorations suggérées à l'Overlay lors du vote, puis étudier les relations entre les risques utilisateur, les critères de réception et l'adaptation « sur-mesure » de la VV&A.
- 3) L'OTAN devrait, au besoin, envisager de collaborer de la même façon avec les organismes normatifs internationaux.

Chapter 1 – INTRODUCTION

1.1 BACKGROUND

The idea for an Exploratory Team on Verification, Validation, and Accreditation (VV&A) of Federations was first proposed during the 5th NATO Modelling and Simulation Group (NMSG) meeting in July 2000. Following initial preliminary discussions and a short meeting by interested parties in September 2000 at the United States Defense Modeling and Simulation Office (DMSO), it became clear that sufficient interest and substance existed for the formation of a Task Group (TG) on the subject.

Credibility is critical to the effective and appropriate use of modelling and simulations (M&S) when used independently or combined in a federation. The cornerstone to establishing M&S credibility is a robust VV&A process. There is a widely disparate understanding of the VV&A process within the NATO/Partners for Peace (PfP) community. Therefore the need exists to establish a consistent baseline of terminology, philosophy, and methodology.

Building a federation that incorporates representations appropriate to the needs of its users relies heavily on the information generated by the VV&A process. Just as the High Level Architecture (HLA) [1] provides the framework that addresses technical interoperability (e.g., issues related to connectivity and data exchange), a well-defined VV&A process supports the establishment of substantive interoperability (e.g., issues related to representations, consistency).

The NATO/PfP community currently has several major initiatives that require the development of M&S federations. The success of these initiatives is tied to the credibility of the federation results and therefore, the VV&A process. This makes definition of a consistent VV&A process even more imperative.

1.2 TASKING

The charter of this Task Group included seven distinct tasks:

- 1) Assess existing NATO and national VV&A products to determine applicability and leverage potential;
- 2) Determine VV&A issues of concern to the success of major NATO/PfP federation initiatives;
- 3) Formulate an outline describing the major elements of the VV&A baseline;
- 4) Evolve the baseline into a Technical Report;
- 5) Capture lessons learned from major NATO/PfP initiatives;
- 6) Revise the baseline to reflect lessons learned; and
- 7) Finalize the Technical Report.

In the course of executing the first task, the Task Group identified, assessed and compared the following products and approaches related to federation VV&A or with possible influence upon VV&A:

- International Test Operations Procedures VV&A Documentation Guidance [2];
- U.S. Department of Defense (DoD) VV&A Recommended Practices Guide [3];

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- VV&A of Federations by V. Dobey and R. Lewis [4];
- Recommended Practice for VV&A of Distributed Interactive Simulations, Institute of Electrical and Electronics Engineers (IEEE) 1278.4 [5];
- German V-Model for Development of Computer-Based Systems [6, 7];
- Universität der Bundeswehr München (UBM) Model of VV&A of Models and Simulations by D. Brade [8];
- Guidelines for VV&A Techniques, THALES JP 11.20 [9, 10, 11];
- U.K./France Joint Study of VV&A of Models and Simulations [12];
- UK Process for VV&A for Synthetic Environments [13, 14];
- U.S. DoD Instruction for VV&A of Models and Simulations, DoDI 5000.61 [15];
- Verification and Validation of Software Systems, IEEE1012 [16];
- Director General (Scrutiny & Analysis) (DG(SRA)) Guidelines for the Verification and Validation of Operational Analysis Modelling Capabilities (Dec 2002) [17]; and
- Naval Sea Systems Command (NAVSEA) Dahlgren Accreditation Team (NDAT) VV&A Process [18, 19].

The Task Group then worked to combine these various concepts for and approaches to VV&A and systems development into an outline for a baseline for federation VV&A. This outline evolved into a draft technical report describing the baseline concepts. The structure of this report closely paralleled the High Level Architecture (HLA) Federation Development and Execution Process (FEDEP), IEEE 1516.3 [20].

Review of this report by a panel of VV&A experts as well as by the authors themselves revealed the disparities between the VV&A approaches of the member nations. The Task Group then decided that a consistent approach to the VV&A of federations could only be successfully developed if it was founded upon a unified model of the underlying VV&A processes.

Shortly after that decision, the First Combined Convention on International VV&A Standardization Endeavours (CConVV&A) [21] defined the relationship between ongoing VV&A initiatives and their associated products. These initiatives included Western European Armament Group Research and Technology program on VV&A (REVVA), International Test Operations Procedures (ITOP), the Simulation Interoperability Standards Organization (SISO) VV&A Overlay Product Development Group (PDG), and NATO Modelling & Simulation Group 019 (MSG-019). As these groups exchanged information about their ongoing efforts and the status of their products, the considerable overlap between the SISO VV&A PDG and NATO MSG-019 became clear. One of the recommendations coming from this convention was that these two efforts be combined. In January of 2005, the two groups met as the VV&A Overlay Drafting Group whose product would be a VV&A overlay to the FEDEP.

This report documents the results of the MSG-019 Task Group efforts to establish the draft VV&A Overlay of the FEDEP. The Overlay has entered the IEEE balloting process and is anticipated to become IEEE 1516.4. A final draft of the Overlay is included as an appendix to this report.

1.3 TASK GROUP MEMBERSHIP

Nations participating in the MSG-019 were Canada, France, Germany, Sweden, the United Kingdom, and the United States. The United States representative served as chair of the Task Group.

1.4 SCOPE OF EFFORT

The area of research this Task Group focused on is the VV&A of federations. The Task Group's scope was to address the issues most critical to the success of the aforementioned NATO/PfP initiatives. The scope of this effort included:

- Identifying and defining the terminology needed to clearly describe the VV&A Overlay processes;
- Characterizing the differences between federate VV&A and federation VV&A and using those differences to distinguish the responsibilities of those participating in federate and federation VV&A;
- Understanding the theoretical nature of the underlying VV&A processes while emphasizing the practical application of that theory;
- Developing a unified model of VV&A processes that addresses the disparate concerns and needs of the member nations;
- Building VV&A guidance based upon actual experience that captures that anecdotal but invaluable knowledge;
- Recognizing the unique role that VV&A plays in the FEDEP that contributes to ensuring that federations can sufficiently serve their intended uses;
- Capturing the assumptions upon which the guidance in the VV&A Overlay is based; and
- Understanding, as much as possible, the nature and extent of tailoring of the VV&A processes.

The scope of this research was also constrained by the assumption that the VV&A Overlay would apply primarily to the development and execution of HLA federations using the FEDEP [20].

While the VV&A Overlay is focused on the FEDEP, users, developers, and VV&A personnel working with simulations and simulation compositions not based upon the HLA can also benefit from the guidance in this document since the activities that this overlay describes can support any type of distributed simulation development.

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Chapter 2 – INTRODUCTION TO THE OVERLAY

The VV&A Overlay has been designed to apply across a wide range of functional applications. The purpose of this Overlay is to provide a more detailed view of the VV&A processes implied by the FEDEP. Currently, these processes represent the best practices available to the VV&A community. The VV&A overlay is a tailorable process and is offered as guidance to all participants in FEDEP activities. Like the FEDEP, the activities of the VV&A Overlay will usually be executed iteratively, rather than linearly, with the successive refinement of its products. The exact nature of any execution thread depends entirely upon the intended use, the federation components and the information needed to support the VV&A processes.

This Overlay identifies and describes the recommended VV&A processes that should be followed to assure the acceptability and utility of federations for particular intended uses. In order to adapt to the needs of individual member nations, this Overlay recognizes that the VV&A processes must always support some form of acceptance of the federations for their intended use, but that only some of those federations will be formally accredited. The overlay also identifies and describes the information feeding and resulting from those processes as well as the relationships between the FEDEP and the VV&A processes and their respective information products. In addition, this overlay defines those terms uniquely needed to characterize the FEDEP VV&A Overlay. This overlay takes special care to use and build upon existing standards, standard terms and their definitions whenever possible.

Finally, as a convenience, this Overlay uses the term “VV&A Team” to refer to those people directly involved in executing the federation VV&A processes. The VV&A Team is not responsible for validating or verifying the individual federates although they do rely upon the products of these activities and may require supplemental verification and validation to gain the information they need for federation VV&A. The VV&A Team does however have primary responsibility for federation validation activities. The membership of the VV&A Team depends upon the needs of the activities being executed, the personnel resources available and the expectations of the federation User/Sponsor.

The VV&A activities described in the overlay, while being generally applicable to most HLA federations, are intended to be tailored to meet the needs of each individual intended use. Every federation application is unique. The extent to which these VV&A processes can be performed for a given federation application will depend on a number of factors, including the quality of the requirements information and the resources allocated to the VV&A Team. The activities recommended in this Overlay should be used as a starting point for developing the specific approach to federation VV&A needed to support the intended use.

Some factors to be considered when tailoring VV&A processes to best fit the circumstances of each individual application include:

- Tailoring is driven by risk and resource constraints (e.g., available information, budget, skills, time);
- Quantifying and minimizing risk are factors that drive tailoring decisions;
- Risk associated with federation use (use risk) is a function of the quality of the federation V&V information;
- The absence of certain information input to the VV&A processes will limit the quality of the content of the VV&A products;
- Tailoring decisions have an impact upon use risk and the resources required, and this impact should be understood and documented;

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- The VV&A processes should leverage testing and data collection tasks and describe this in the Federation Accreditation Plan and V&V Plan;
- Any tailoring should adhere to any existing policies, standards or guidelines that may be relevant to the intended use; and
- Tailoring may be done at any time in the federation VV&A processes.

Chapter 3 – DESCRIPTION OF THE FEDEP

IEEE 1516.3, Recommended Practice for High Level Architecture (HLA) Federation Development and Execution Process (FEDEP), describes an approach for developing M&S federations based on sound systems engineering principles and serves as the foundation for the VV&A Overlay. Figure 3-1 provides a high level view of the major activities associated with the FEDEP. A description of these steps follows Figure 3-1.

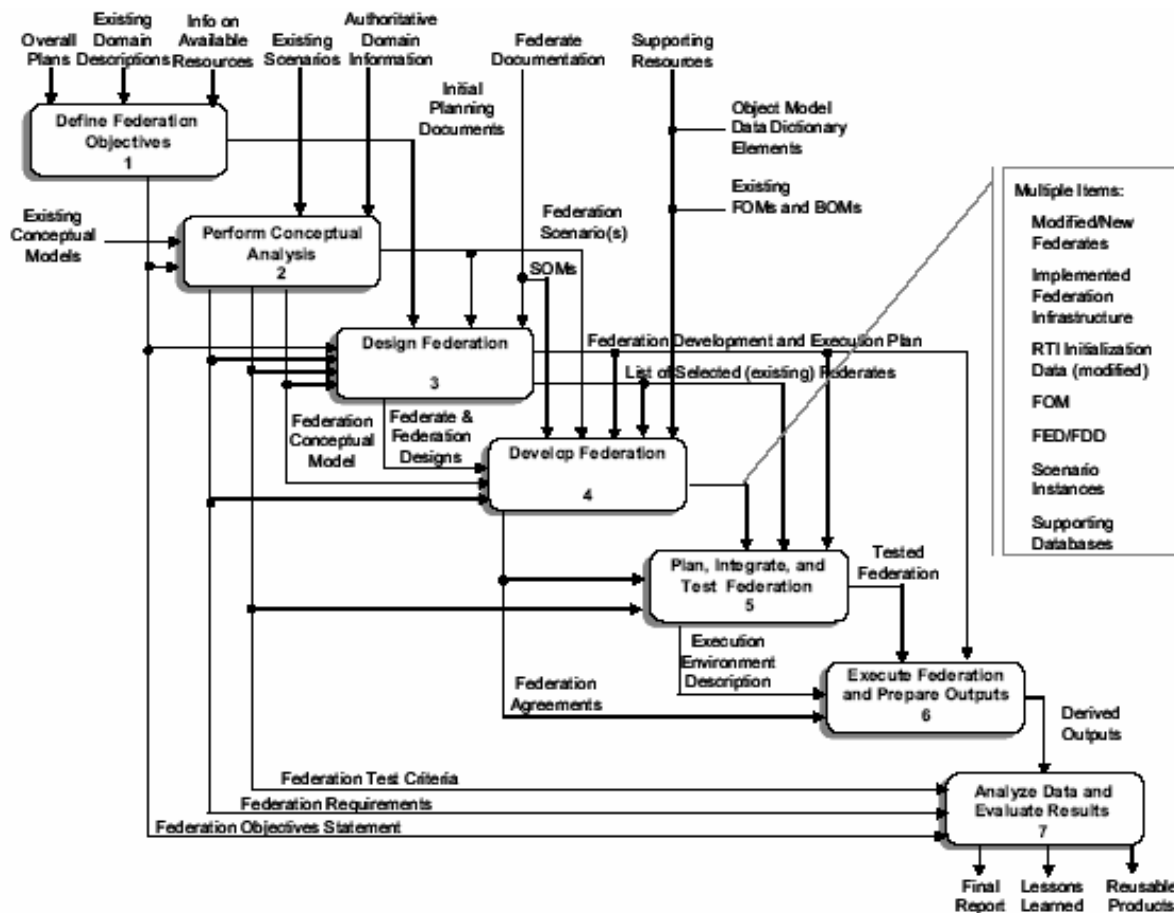


Figure 3-1: Top-Level View of the FEDEP.

Step 1 – Define Federations Objectives. The purpose of step 1 of the FEDEP is to define and document a set of needs that are to be addressed through the development and execution of an HLA federation and to transform these needs into a more detailed list of federation objectives.

Step 2 – Perform Conceptual Analysis. The purpose of this step of the FEDEP is to develop an appropriate representation of the real world domain that applies to the federation problem space and to develop the federation scenario. It is also in this step that federation objectives are transformed into a set of highly specific federation requirements that will be used in federation design, development, testing, execution, and evaluation.

DESCRIPTION OF THE FEDEP

Step 3 – Design Federation. The purpose of this step of the FEDEP is to produce the design of the federation that will be implemented in step 4. This involves identifying existing federates that are suitable for reuse, creating new federates and federate components (if required) allocating the required functionality to federates, and developing a detailed plan for federation development and implementation.

Step 4 – Develop Federation. The purpose of this step of the FEDEP is to develop the Federation Object Model (FOM), modify federates if necessary, and prepare the federation for integration and test.

Step 5 – Plan, Integrate, and Test Federation. The purpose of this step of the FEDEP is to plan the federation execution, establish all required interconnectivity between federates, and test the federation prior to execution.

Step 6 – Execute Federation and Prepare Outputs. The purpose of this step of the FEDEP is to execute the federation and to pre-process the output data from the federation execution.

Step 7 – Analyze Data and Evaluate Results. The purpose of this step of the FEDEP is to analyze and evaluate the data acquired during the federation execution, and to support the results back to the user/sponsor. This evaluation is necessary to assess that the federation fully satisfies the requirements of the user/sponsor. The results are fed back to the user/sponsor so that they can decide if the federation objectives have been met, or if further work is required.

Chapter 4 – VV&A ACTIVITIES DEFINED

4.1 TOP-LEVEL VIEW OF THE VV&A OVERLAY

As in the FEDEP, one of the design goals identified during the development of this VV&A overlay was to define a highly flexible process. This facilitates tailoring the VV&A activities defined in this overlay as the user needs and resource constraints demand. The actual application of VV&A techniques to support the development of a federation could vary significantly within or across different intended uses. However, the VV&A phases that correspond to the FEDEP steps establish a foundation for applying VV&A within the FEDEP. Figure 4-1 illustrates each of the FEDEP steps together with the corresponding VV&A overlay phases.

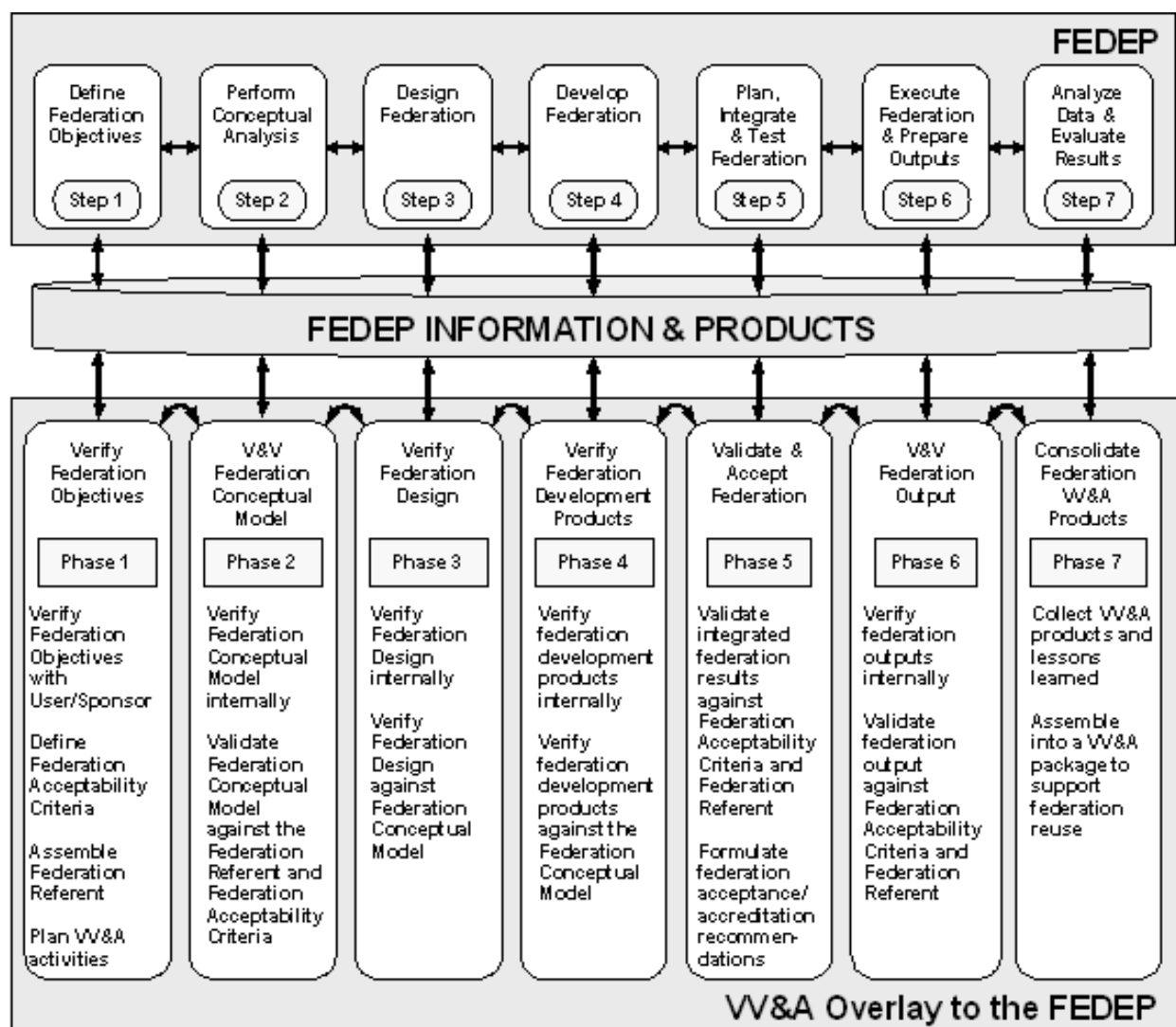


Figure 4-1: Top-Level View of the VV&A Overlay to the FEDEP.

VV&A ACTIVITIES DEFINED

The purpose for each of the overlay phases is summarized below:

Phase 1 – Verify Federation Objectives. The VV&A Team works as part of the Federation Development Team to define a set of Federation Objectives and verify the completeness, consistency, and correctness of those objectives with the User/Sponsor. The VV&A Team also assembles the Federation Referent, defines the Federation Acceptability Criteria, and formulates the initial Federation Accreditation Plan and V&V Plan at this time.

Phase 2 – V&V Federation Conceptual Model. The VV&A Team supports the Federation Development Team in developing the Federation Scenarios, Federation Conceptual Model, and Federation Requirements. They also contribute to verifying these products and are responsible for validating the Federation Conceptual Model.

Phase 3 – Verify Federation Design. The VV&A Team supports selecting the federates and preparing the Federation Design. They also contribute to verifying the Federation Design and provide an updated Federation Accreditation Plan and V&V Plan for inclusion into the Federation Development and Execution Plan.

Phase 4 – Verify Federation Development Products. The VV&A Team supports developing the FOM, establishing the Federation Agreements, and implementing the Federation Infrastructure. They also contribute to verifying the FOM, Federation Agreements, and Federation Infrastructure. They provide any support needed to verify and validate the federate implementations and collect the information from these V&V processes. Finally, they verify and validate the data sets needed for federation execution.

Phase 5 – Validate and Accept Federation. The VV&A Team supports the Federation Development Team in planning the federation execution, integrating the federation, and testing the federation. They also contribute to verifying the integrated federation. They have primary responsibility for validating the results produced by the integrated federation and developing the federation acceptance/accreditation recommendations from the collected V&V evidence.

Phase 6 – V&V Federation Output. The VV&A Team supports executing the federation when needed and contributes to verifying the raw execution and derived output produced from these executions. They then validate the federation output when needed.

Phase 7 – Consolidate Federation VV&A Products. The VV&A Team supports analyzing the federation output when needed and collects and assembles the products from the preceding VV&A activities into a consolidated package to support future reuse.

The seven phases in this overlay parallel the seven steps in the FEDEP. As in the FEDEP, this overlay decomposes each of the VV&A phases into a set of interrelated lower-level activities and supporting information resources.

4.2 OVERVIEW OF THE VV&A OVERLAY ACTIVITIES

The VV&A overlay describes a high level framework for the verifying, validating, and accepting HLA federations. The intent of the VV&A overlay is to specify a recommended practice that details the VV&A phases that correspond to, support, and augment the FEDEP steps. Federation stakeholders can leverage this overlay to achieve the specific needs associated with their intended use.


```

graph TD
    Plan[Federation Accreditation Plan, Federation Acceptability Criteria, Federation Referent, Federation V&V Plan]
    
    subgraph Phase1 [Phase 1]
        VFO[Verify Federation Objectives]
    end
    
    subgraph Phase2 [Phase 2]
        VFCM[V&V Federation Conceptual Model]
    end
    
    subgraph Phase3 [Phase 3]
        VFD[Verify Federation Design]
    end
    
    subgraph Phase4 [Phase 4]
        VFDP[Verify Federation Development Products]
    end
    
    subgraph Phase5 [Phase 5]
        VAF[Validate & Accept Federation]
    end
    
    subgraph Phase6 [Phase 6]
        VFO2[V&V Federation Output]
    end
    
    subgraph Phase7 [Phase 7]
        CFVAP[Consolidate Federation V&A Products]
    end
    
    DFO([Define Federation Objectives])
    PCA([Perform Conceptual Analysis])
    DF([Design Federation])
    DEV([Develop Federation])
    PITF([Plan, Integrate and Test Federation])
    EFPO([Execute Federation and Prepare Outputs])
    ADER([Analyze Data and Evaluate Results])
    
    VFO --> DFO
    VFO --> PCA
    VFO --> DF
    VFO --> DEV
    VFO --> PITF
    VFO --> EFPO
    VFO --> ADER
    
    DFO -- "verified Federation Objectives" --> PCA
    PCA -- "validated Federation Conceptual Model" --> DF
    DF -- "verified Federation Design" --> DEV
    DEV -- "verified federation development products" --> PITF
    PITF -- "accepted federation" --> EFPO
    EFPO -- "validated federation output" --> ADER
    
    VFCM --> PCA
    VFCM --> DF
    VFCM --> DEV
    VFCM --> PITF
    VFCM --> EFPO
    VFCM --> ADER
    
    VFD --> DF
    VFD --> DEV
    VFD --> PITF
    VFD --> EFPO
    VFD --> ADER
    
    VFDP --> DEV
    VFDP --> PITF
    VFDP --> EFPO
    VFDP --> ADER
    
    VAF --> PITF
    VAF --> EFPO
    VAF --> ADER
    
    VFO2 --> EFPO
    VFO2 --> ADER
    
    CFVAP --> ADER
    
    DFO --> R1[Federation Conceptual Model V&V results]
    PCA --> R2[Federation Design verification results]
    DF --> R3[federation development verification results]
    DEV --> R4[federation validation and acceptance results]
    PITF --> R5[federation output V&V results]
    EFPO --> R6[federation V&A products]
    
    R1 --> VFCM
    R2 --> VFD
    R3 --> VFDP
    R4 --> VAF
    R5 --> VFO2
    R6 --> CFVAP
  
```

Figure 4-2: Detailed View of the VV&A Overlay to the FEDEP.

Figure 4-3 identifies the individual activities that compose each of the VV&A phases that correspond to the FEDEP's seven steps.

VV&A ACTIVITIES DEFINED

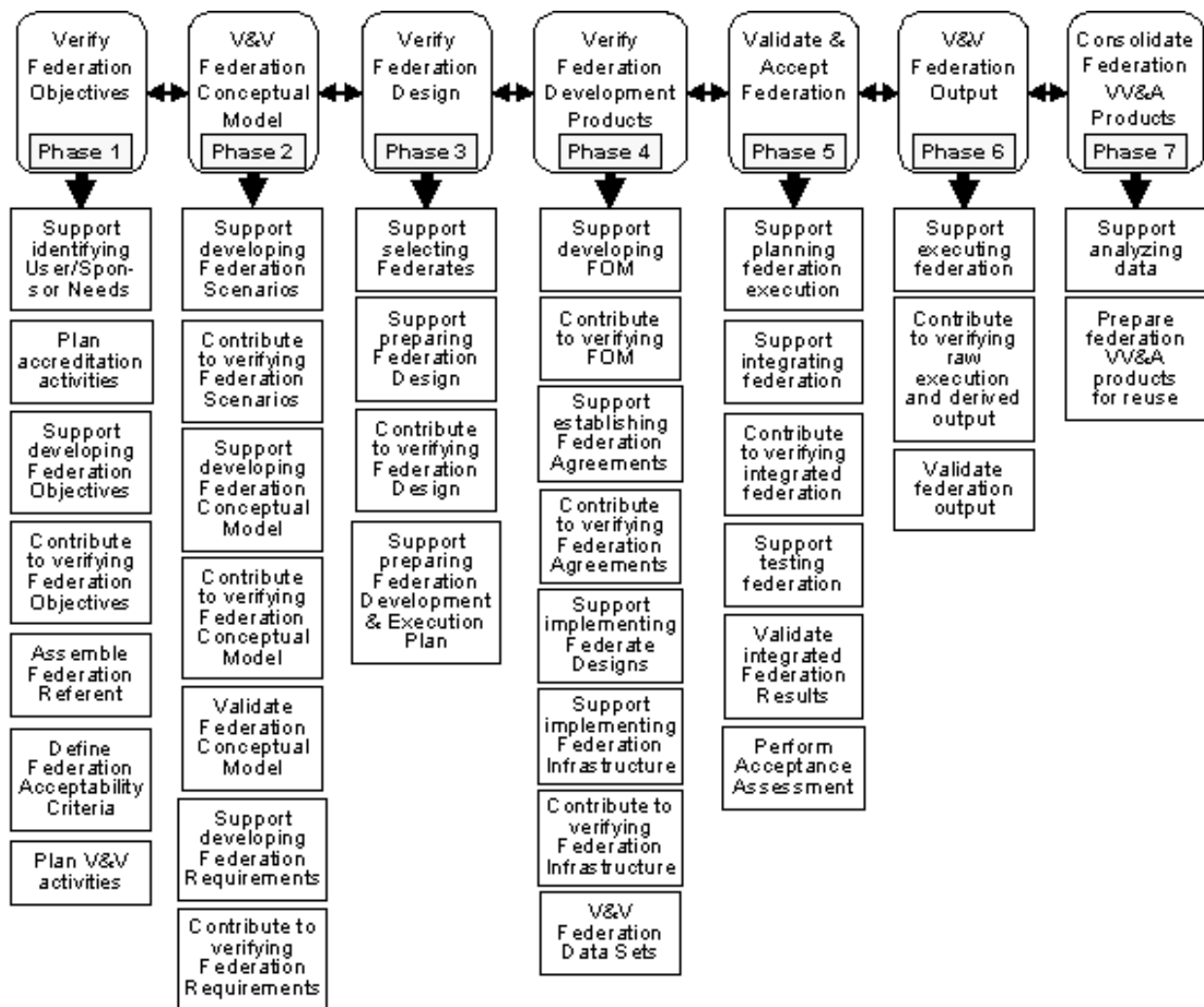


Figure 4-3: Activities Associated with Each VV&A Overlay Phase.

Although many of the activities represented in this overlay diagram appear highly sequential, the intention is not to suggest a strict waterfall approach to VV&A. Rather, this process illustration is simply intended to highlight the major VV&A activities that occur during federation development and execution and approximately when such activities are first initiated relative to other VV&A or FEDEP activities.

Chapter 5 – CONCLUSIONS AND RECOMMENDATIONS

When MSG-019/TG-016 was established, both the NATO and the distributed simulation communities had realized a need for guidance about the VV&A of federations. The efforts of this Task Group addressed this need for both communities. In the course of addressing the common need for federation VV&A, the Task Group began to develop a baseline view of VV&A. This view emphasized the lack of a universal model for federation VV&A processes due to divergent national perspectives and needs. The Task Group determined that the lack of this consistent methodology was hampering NATO's ability to develop shared simulation federations. Resolving these disparities required developing a consistent understanding of what VV&A is and how to apply it to achieve the best results. Even though the member nations came from different perspectives, they were able to converge onto a single unified model of federation VV&A processes. Thus, the baseline and the results from the CConVV&A [21] resulted in a decision to merge the efforts of this Task Group and the SISO VV&A Overlay drafting group. This merge expanded the focus of this Task Group to go beyond preparing a technical report to actually producing a VV&A Overlay standard product. The Task Group also identified several terms needed to describe VV&A processes for federations and developed definitions for these terms using existing standard definitions.

Formalizing the Overlay as an IEEE standard was determined to be the most appropriate standardization approach as it provides international recognition and access; co-locates the Overlay with its companion document IEEE standard 1516.3 for the HLA FEDEP [20]; and provides maintenance and management of the Overlay by IEEE. The proposed IEEE standard (1516.4) addresses the needs of both the NATO and SISO communities for a VV&A Overlay to the FEDEP.

This Task Group succeeded because of extensive collaboration with other international groups including SISO, REVVA and ITOP. The tight coupling between the NATO and SISO groups resulted in a better, more widely applicable Overlay (e.g., government, industry, and academia). The collaboration benefited NATO by directly coupling the MSG product to an internationally recognized standards body and benefited SISO by ensuring early and extensive international input to the final product. This collaborative effort could serve as a model for future joint M&S standards initiatives.

While the Task Group feels that enormous strides have been made with the development of the VV&A Overlay, still more work is needed to increase the effectiveness and efficiency of the VV&A processes. Particular areas to be addressed include case studies to mature the Overlay, tailoring the VV&A processes based on user risk management, and effective communication of risk to program management.

Based on the above conclusions, the Task Group makes the following recommendations:

- NATO should adopt Appendix 1 as an interim Standardization Agreement (STANAG) until the IEEE 1516.4 standard is issued and then revise the STANAG to adopt the IEEE standard.
- MSG-054, the follow-on study group, should:
 - Participate in the IEEE 1516.4 balloting process;
 - Monitor on-going VV&A case study initiative and incorporate suggested improvements to the Overlay during the balloting process; and
 - Study the relationship between user risk, acceptance criteria, and tailoring of the VV&A process.
- NATO should consider adopting similar collaborative relationships with international standards bodies as appropriate.

CONCLUSIONS AND RECOMMENDATIONS



Chapter 6 – DEFINITIONS

Acceptability Criteria: The criteria that the federation needs to meet to be acceptable for its intended use.

Acceptance: The decision to use the results produced by a federation for an intended use.

Accreditation: The official certification that a model or simulation is acceptable for use for a specific purpose.

Activity: A set of tasks that consumes time and resources and whose performance is necessary for the execution of the federation development and execution process.

Federate: An application that may be or is currently coupled with other software applications under a Federation Object Model Document Data/Federation Execution Data and a runtime infrastructure (e.g., federation managers, data collectors, real world (live) systems (e.g., Command, Control, Communications, Computers, and Intelligence (C4I) systems, instrumented ranges, sensors), simulations, passive viewers, and other utilities).

Federation: A named set of federate applications and a common Federation Object Model (FOM) that are used as a whole to achieve some specific objective.

Federation Conceptual Model: An abstraction of the real world that serves as a frame of reference for federation development by documenting simulation-neutral views of important entities and their key actions and interactions.

Federation Object Model: A specification defining the information exchanged at runtime to achieve a given set of federation objectives.

Federation Objectives: The statement of the problem that is to be addressed by the establishment and execution of a federation.

Federation Requirements: A statement that identifies a federation characteristic, constraint, process, or product that is unambiguous and testable and that is necessary for a federation to be acceptable for its intended use.

Federation Scenario: a set of initial conditions and time line of significant events used within a federation execution to achieve federation objectives.

Referent: A codified body of knowledge about a thing being simulated.

Validation: The process of evaluating a federation throughout the development and execution process to determine how well it satisfies the acceptability criteria within the context of the referent.

Verification: The process of evaluating a federation and its intermediate products to determine whether the products from a given development phase satisfy the conditions imposed at the start of that phase and, ultimately, determining that an implementation of a federation correctly and completely represents the developer's conceptual description and specifications.

DEFINITIONS



Chapter 7 – ACRONYMS

C4I	Command, Control, Communications, Computers, and Intelligence
CConVV&A	Combined Convention on International VV&A Standardization Endeavours
DG(SRA)	Director General (Scrutiny & Analysis) (UK)
DMSO	Defense Modeling & Simulation Office (US)
DoD	Department of Defense (US)
Dstl	Ministry of Defence, Defence Science and Technology Laboratory (UK)
Euro-SIW	European Simulation Interoperability Workshop
FEDEP	Federation Development and Execution Process
FMV	Försvarets materielverk (Sweden)
FOM	Federation Object Model
HLA	High Level Architecture
IEEE	Institute of Electrical and Electronics Engineers
ITEC	International Training and Education Conference
ITOP	International Test Operations Procedures
M&S	Modelling & Simulation
MSG-019	Modelling & Simulation Group 019
MSG-054	Modelling & Simulation Group 054
NATO	North Atlantic Treaty Organisation
NAVSEA	Naval Sea Systems Command (US)
NDAT	NAVSEA Dahlgren Accreditation Team (US)
NMSG	NATO Modelling and Simulation Group
PDG	Product Development Group
REVVA	WEAG Research and Technology program on VV&A (JP11.20)
RPG	Recommended Practices Guide (US)
SISO	Simulation Interoperability Standards Organization
SIW	Simulation Interoperability Workshop
STANAG	Standardization Agreement

ACRONYMS

TG	Task Group
UBM	Universität der Bundeswehr München (Germany)
V&V	Verification and Validation
VV&A	Verification, Validation, & Accreditation
WEAG	Western European Armament Group

Chapter 8 – HISTORY OF MEETINGS

2001	December	Paris, France	
2002	April	Lille, France	In conjunction with International Training and Education Conference (ITEC).
2002	October	Laurel, MD, US	In conjunction with the Foundations '02 Workshop at The Johns Hopkins University Applied Physics Lab.
2003	January	Munich, Germany	
2003	May	Paris, France	
2003	September	London, UK	
2003	December	Washington, DC, US	
2004	April	Munich, Germany	
2004	June	Stockholm, Sweden	
2004	October	Munich, Germany	In conjunction with the First Combined Convention on International VV&A Standardization Endeavours (CConVV&A).
2005	January	Orlando, FL, US	First meeting of combined SISO VV&A PDG and NATO MSG-019 as Overlay drafting group.
2005	April	San Diego, CA, US	In conjunction with Spring Simulation Interoperability Workshop (SIW).
2005	June	Paris, France	In conjunction with Euro-SIW meeting in Toulouse, France.
2005	September	Orlando, FL, US	In conjunction with Fall SIW.
2005	October	St. Goar, Germany	
2006	January	Malvern, UK	
2006	April	Huntsville, AL, US	In conjunction with Spring SIW.
2006	June	Ottawa, Canada	
2006	September	Orlando, FL, US	In conjunction with Fall SIW.

HISTORY OF MEETINGS



Chapter 9 – REFERENCES

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Appendix 1 – VV&A OVERLAY TO THE FEDEP

Draft Recommended Practice for Verification, Validation, and Accreditation of a Federation, an Overlay to the High Level Architecture Federation Development and Execution Process

1.0 OVERVIEW

1.1 Scope

This recommended practice defines the processes and procedures that should be followed to implement Verification, Validation, and Accreditation¹ (VV&A) for federations being developed using the High Level Architecture (HLA) Federation Development and Execution Process (FEDEP). This recommended practice is not intended to replace existing VV&A policies, procedures, and guidance, but rather is intended to focus on the unique aspects of the VV&A of federations. It provides a higher-level framework into which such practices can be integrated and tailored for specific uses. The VV&A overlay provides implementation-level guidance to VV&A practitioners; however, it does not describe the individual techniques that might be employed to execute the VV&A processes for federations.

This VV&A overlay focuses upon the VV&A processes that apply to federations and not the VV&A processes associated with individual simulations (federates), but does consider using the information produced by those processes.

Users, developers, and VV&A personnel working with simulations and simulation compositions not based upon the HLA and the FEDEP can also benefit from the guidance in this document since the activities that this overlay describes can be tailored to support any type of distributed simulation application.

1.2 Purpose

The VV&A overlay has been designed to apply across a wide range of functional applications. The purpose of this overlay is to provide a more detailed view of the VV&A processes implied by the FEDEP. Currently, these processes represent the best practices available to the VV&A community. The VV&A overlay is a tailorable process and is offered as guidance to all participants in FEDEP activities.

This overlay identifies and describes the recommended VV&A processes that should be followed to assure the acceptability and utility of federations for particular intended uses. The overlay also identifies and describes the information feeding and resulting from those processes as well as the relationships between the FEDEP and the VV&A processes and their respective information products. In addition, this overlay defines those terms uniquely needed to characterize the FEDEP VV&A overlay. This overlay takes special care to use and build upon existing standards, standard terms and their definitions whenever possible.

¹ Note that outside of the United States there may not be a formal accreditation process and the terms “acceptance” or “accepted for use” may be used; in this document the term acceptance is the decision to use a model, simulation, or federation of models and simulations for a specific purpose and the term accreditation is the official certification that a model, simulation, or federation of models and simulations is acceptable for use for a specific purpose. For the purposes of this document the terms are equivalent.

APPENDIX 1 – VV&A OVERLAY TO THE FEDEP

1.3 Conventions

This section describes the conventions adopted for presenting the overlay material. The overlay employs three types of conventions: capitalization, special words, and graphic symbols. These conventions are used throughout the overlay as much as possible.

The overlay uses capitalization to identify the key participants in the VV&A processes. The overlay distinguishes between the Federation Development Team and the VV&A Team, and capitalizes the references to these teams. The VV&A Team may participate as part of the Federation Development Team. The VV&A Team may participate as part of the Federation Development Team; however, the VV&A Team may or may not be organizationally independent of it.

The titles of the primary information produced or needed by these teams are also capitalized (e.g., Federation Objectives, Federation Acceptability Criteria, and Federation Referent). This information includes that produced by both the Federation Development Team (e.g., Federation Objectives and Federation Conceptual Model) and the VV&A Team (e.g., Federation Acceptability Criteria and Federation Referent). Any modifiers describing those information items are not capitalized (e.g., initial Federation V&V Plan, revised Federation V&V Plan, validated Federation Conceptual Model) as part of the title. These capitalization conventions emphasize the content of the information produced.

The overlay uses a few words in very specific ways. It divides the VV&A processes applied to federations into phases, activities, and tasks. Phases correspond to the seven top-level FEDEP steps. Each phase contains several activities and each activity includes a set of tasks that the VV&A Team executes to accomplish the activity.

The overlay also distinguishes between the three types of VV&A Team participation in the FEDEP:

- Supporting;
- Contributing to; and
- Responsible for performing.

The overlay consistently begins both activity titles and task descriptions with the verbs corresponding to these types and uses this convention throughout the document. This distinction occurs because of the many different players in the FEDEP and the variety of ways in which various responsibilities may be assigned to these players.

All activity titles and task descriptions that begin with the verb “support” represent those activities or tasks that the FEDEP explicitly identifies and that the VV&A Team can support in some way. Activities with “support” titles are generally led or performed by a member of the Federation Development Team, but require the involvement of the VV&A Team. A “support” activity may contain tasks that the FEDEP does not explicitly identify. The VV&A Team performs these tasks and assumes the responsibility for satisfactorily completing them.






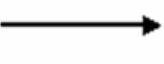

The activity titles and task descriptions that begin “contribute to” represent verification activities and tasks and need to be accomplished to ensure the success of the VV&A effort. As a result, the VV&A Team may need to be involved in performing these activities and tasks, but will generally not take primary responsibility for their completion. However, this does not imply that the VV&A Team does not perform verification activities. On the contrary, the VV&A Team may need to perform verification where they need the information to supplement that

received from the verification that other members of the Federation Development Team have performed. In some cases, the VV&A Team may need to assume responsibility for performing the “contribute to” activities and tasks when that responsibility has been assigned to no other member of the Federation Development Team. This may be needed so that the VV&A Team can perform the duties for which they do have explicit responsibility.

Those activity titles and task descriptions that begin with some other verb (e.g., plan, validate, perform, prepare) represent the activities and tasks for which the VV&A Team has primary responsibility and will perform. These activities and tasks are essential to creating a valid federation. Consistent with these conventions, these VV&A-specific tasks do not begin with either the “support” or “contribute to” verbs.

Each phase described in this overlay has an activity diagram associated with it that shows the primary relationships between the VV&A activities in the phase and the activities in the corresponding FEDEP step. These diagrams use particular symbols to identify the types of VV&A activities and their interactions. The Table A1-1 below describes the meanings of these symbols.

Table A1-1: Symbol Conventions Used in the Activity Diagrams

Symbol	Meaning
	A FEDEP activity
	An activity that directly supports a corresponding FEDEP activity
	An activity to which the VV&A Team contributes and may perform if needed
	An activity that the VV&A Team uniquely performs, leads, and takes responsibility for its satisfactory completion
	Data sets needed to support a FEDEP execution
	A primary information flow from one activity to another or from one VV&A phase to another
	A connection between two information flows

These activity diagrams label each VV&A activity with a number designation (X,Y) to show the traceability between the phase (X) with which the activity is associated and the activity (Y). The activity numbers in these diagrams are only identifiers and do not imply any ordering of activity execution.

These activity diagrams present only abstractions of the details provided in the activity discussions. These diagrams are intended only as illustrations to clarify the key elements of the phases they described. The activity diagrams show only the primary information exchanged and do not include all of the information

APPENDIX 1 – VV&A OVERLAY TO THE FEDEP

involved in the activity interactions. The information illustrated in these diagrams either identifies what is important to the VV&A effort or emphasizes the value added by the VV&A activities. The activity discussions provide more extensive lists of the information inputs and outputs. The abstraction inherent to these diagrams is not intended to imply that these activities do not draw upon information prepared in the preceding phases. The conventions for these diagrams are informal, do not adhere to the specifications of formal diagramming conventions and are provided only for illustrative purposes.

2.0 REFERENCES

The three specifications that compose the HLA, together with the FEDEP, provide the technical foundation for designing and developing all HLA federations. These specifications are described in the following documents:

IEEE Std 1516™-2000, IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) – Framework and Rules.

IEEE Std 1516.1™-2000, IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) – Federate Interface Specification.

IEEE Std 1516.2™-2000, IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) – Object Model Template (OMT) Specification.

IEEE Std 1516.3™-2003 IEEE Recommended Practice For High Level Architecture (HLA) Federation Development and Execution Process (FEDEP).

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3.0 DEFINITIONS, ACRONYMS, AND ABBREVIATIONS

The following terms and definitions apply to this recommended practice. The Authoritative Dictionary of IEEE Standards, Seventh Edition, should be referenced for terms not defined in this clause.

3.1 Definitions

Acceptability Criteria: The criteria that the model, simulation, or federation of models and simulations needs to meet to be acceptable for its intended use.

Acceptance: The decision to use the results produced by a model, simulation, or federation of models and simulations for an intended use.

Accreditation: The official certification that a model, simulation, or federation of models and simulations is acceptable for use for a specific purpose (see DoDI 5000.61).

Activity: A set of tasks that consumes time and resources and whose performance is necessary for the execution of the federation development and execution process.

Credibility: The belief that a model, simulation, or federation of models and simulations can serve an intended use.

Error Characteristics: Those characteristics that describe the nature of the errors in the output from a model, simulation, or a federation of models and simulations. For each output variable that can assume metric values, the minimum and maximum error bounds are measured from the values established by the referent under the same conditions together with the probability that all errors of the output values for that variable will fall within those error bounds.

Federate: An application that may be or is currently coupled with other software applications under a Federation Object Model Document Data/Federation Execution Data and a runtime infrastructure (e.g., federation managers, data collectors, real world (live) systems (e.g., C4I systems, instrumented ranges, sensors), simulations, passive viewers, and other utilities) (see IEEE 1516.3™-2003).

Federation: A named set of federate applications and a common Federation Object Model (FOM) that are used as a whole to achieve some specific objective (see IEEE 1516.3™-2003).

Federation Conceptual Model: An abstraction of the real world that serves as a frame of reference for federation development by documenting simulation-neutral views of important entities and their key actions and interactions (see IEEE 1516.3™-2003).

Federation Object Model: A specification defining the information exchanged at runtime to achieve a given set of federation objectives (see IEEE 1516.3™-2003).

Federation Objectives: The statement of the problem that is to be addressed by the establishment and execution of a federation (see DoD 5000.59-M).

Federation Requirements: A statement that identifies a federation characteristic, constraint, process, or product that is unambiguous and testable and that is necessary for a federation to be acceptable for its intended use.

Federation Scenario: a set of initial conditions and time line of significant events used within a federation execution to achieve federation objectives.

Fidelity: The description of a model, simulation, or federation of models and simulations and its associated data representational capabilities (e.g., resolution, error, precision, sensitivity).

Interoperability: The ability of a federate to provide services to and/or accept services from other federates and to use the services so exchanged to enable the federates to operate effectively together.

Referent: A codified body of knowledge about a thing being simulated (see Verification, Validation, and Accreditation (VV&A) Recommended Practices Guide, Build 2.5).

Representational Requirements: That subset of the modeling and simulation requirements that specifically describes the required states or behavior of the things that the simulation represents, including the modeled entities, their properties, and their dependencies (see Verification, Validation, and Accreditation (VV&A) Recommended Practices Guide, Build 2.5).

Results Sampling Strategy: The approach for collecting the output from a model, simulation, or federation of models and simulations.

Risk: A measure of the probability and severity of undesired effects often taken as the simple product of probability and consequence (see The Authoritative Dictionary of IEEE Standards Terms, Seventh Edition).

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Traceability: The degree to which a relationship can be established between two or more products of the development process, especially products having a predecessor-successor or master-subordinate relationship to one another; for example, the degree to which the requirements and design of a given system element match (see The Authoritative Dictionary of IEEE Standards Terms, Seventh Edition).

Uncertainty: A quantity or quantities that indicate the degree of doubt associated with the value of a simulated or referent property; for enumerated values, the probability that the actual enumerated value corresponds with the simulated or referent value under the same conditions; for metric values, the error characteristics associated with the simulated or referent value.

Validation: The process of evaluating a model, simulation, or federation of models and simulations throughout the development and execution process to determine how well it satisfies the acceptability criteria within the context of the referent.

Validity: The property of a model, simulation, or federation of models and simulations representations being complete and correct enough for the intended use.

Verification: The process of evaluating a model, simulation, or federation of models and simulations and its intermediate products to determine whether the products from a given development phase satisfy the conditions imposed at the start of that phase and, ultimately, determining that an implementation of a model, simulation, or federation of models and simulations correctly and completely represents the developer's conceptual description and specifications.

3.2 Acronyms and Abbreviations

FEDEP	Federation Development and Execution Process
FOM	Federation Object Model
HLA	High Level Architecture
IEEE	Institute of Electrical and Electronics Engineers
M&S	Modeling and Simulation
SOM	Simulation Object Model (of a federate)
V&V	Verification and Validation; Verify and Validate
VV&A	Verification, Validation, and Accreditation

4.0 FEDERATION VV&A ROLES AND RESPONSIBILITIES

This section introduces the various roles and responsibilities that are required to perform each activity identified in the VV&A Overlay. The person or persons who perform in the roles needed to accomplish the activities in this overlay comprise the VV&A Team. The section also describes the rationale used to identify and classify these roles and responsibilities.

The roles and responsibilities defined are not intended to map directly to specific people or organizations. There are cases where one individual or organization may have several of the roles. The delegation of these

responsibilities depends upon the available resources. The resources required to support each of these roles depends on the User/Sponsor requirements and the complexity of the federates and federations. If these resources are not available, then some prioritization and tailoring of the tasks and their assignment to the roles will be necessary.

Table A1-2 identifies the roles and responsibilities relevant to VV&A for each activity in this overlay. They are intended only as general guidelines. Interpreting Table A1-2 requires understanding the actions attributed to the roles and the heuristics used to assign the actions to the roles.

The following actions are used in Table A1-2 and in the heuristics used to construct that table. They can apply to either an organization or an individual:

- **Lead (L)** Responsible for the activity including assignment of actions to others and scheduling.
- **Perform (P)** Responsible for performing an activity or task under the direction of the leader of the activity.
- **Assist (AST)** Help a performer or a leader complete an activity or task.
- **Review (R)** Called upon to review the work of others and to make suggestions for improvement where appropriate.
- **Monitor (M)** Will watch the activities being performed or receive the products so that they can be aware of the VV&A status.
- **Approve (AP)** Responsible for approving the VV&A-related products.

The following heuristics were used to develop Table A1-2:

- Federation related (non VV&A) activities are led or performed by the Federation Manager or Federation Developer;
- Verification activities may be led or performed by the Federation Developer and assisted by the V&V Agent; or led and performed by the V&V Agent, if needed;
- Validation activities are led or performed by the V&V Agent;
- Accreditation activities are led or performed by the Accreditation Agent;
- For “support” activities, the V&V Agent or the Accreditation Agent generally monitor or assist; and
- For “contribute to” activities, the V&V Agent or the Accreditation Agent may either assist or perform.

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Table A1-2: Roles and Responsibilities

VV&A Overlay Phases and Activities L = Lead, P = Perform, AST = Assist, R = Review, M = Monitor, AP = Approve		User / Sponsor	Federation Manager	Federation Developer	V&V Agent	Accreditation Agent	Subject Matter Expert
Phase 1 - Verify federation objectives							
Activity 1.1	Support identifying user/sponsor needs	AST, AP	L, P	AST	M	AST	AST
Activity 1.2	Plan accreditation activities	R, AP	AST		AST	L, P	AST
Activity 1.3	Support developing federation objectives	AST, AP	L, P	AST	M	AST	AST
Activity 1.4	Contribute to verifying federation objectives	AP	L	P	AST	AST	AST
Activity 1.5	Assemble federation referent	AST, AP	M	AST, P	AST	L, P	AST
Activity 1.6	Define federation acceptability criteria	AST, AP	M	AST	AST	L, P	AST
Activity 1.7	Plan V&V activities	R	AST, AP	R	L, P	AST	AST
Phase 2 - V&V federation conceptual model							
Activity 2.1	Support developing federation scenarios	AP	L	P	AST	M	P, AST
Activity 2.2	Contribute to verifying federation scenarios		M	L, P	AST	M	P, AST
Activity 2.3	Support developing federation conceptual model	AP	L	P	AST	M	P, AST
Activity 2.4	Contribute to verifying federation conceptual model		M	L, P	AST	M	P, AST
Activity 2.5	Validate federation conceptual model	AP	M	AST	L, P	M	P, AST
Activity 2.6	Support developing federation requirements	AST, AP	L, P	AST	AST	M	AST
Activity 2.7	Contribute to verifying federation requirements	AP	L	P	AST	M	AST
Phase 3 - Verify federation design							
Activity 3.1	Support selecting federates	AP	L	P	AST	M	AST
Activity 3.2	Support preparing federation design	AP	L	P	AST	M	AST
Activity 3.3	Contribute to verifying federation design		M	L, P	AST	M	AST
Activity 3.4	Support preparing federation development and execution plan	AP	L	P	AST	AST	AST
Phase 4 - Verify federation development products							
Activity 4.1	Support developing FOM		L, AP	P	AST	M	AST
Activity 4.2	Contribute to verifying FOM		AST	L, P	AST	M	AST
Activity 4.3	Support establishing federation agreements	AP	L, P	AST	AST	M	AST
Activity 4.4	Contribute to verifying federation agreements		L	P	AST	M	AST
Activity 4.5	Support implementing federate designs		L	P	AST	M	AST
Activity 4.6	Support implementing federation infrastructure	AST	L	P	AST	M	
Activity 4.7	Contribute to verifying federation infrastructure		M	L, P	AST	M	
Activity 4.8	Verify and validate federation data sets	AP	M	P	L, P	M	P, AST
Phase 5 - Validate and accept federation							
Activity 5.1	Support planning federation execution	AST	L, P	AST	AST	M	AST
Activity 5.2	Support integrating federation		L	P	AST	M	AST
Activity 5.3	Contribute to verifying integrated federation		M	L, P	AST	M	AST
Activity 5.4	Support testing federation	M	L	P	AST	M	AST
Activity 5.5	Validate integrated federation results		M	AST	L, P	M	P, AST
Activity 5.6	Perform acceptance assessment	AP	M	AST	AST	L, P	P, AST
Phase 6 - Verify and validate federation output							
Activity 6.1	Support executing federation	P, M	L	P, AST	AST	M	P, AST
Activity 6.2	Contribute to verifying raw execution and derived output	P, M	L	P, AST	AST	M	P, AST
Activity 6.3	Validate federation output	AP	AST	AST	L, P	AST	P, AST
Phase 7 - Consolidate federation VV&A products							
Activity 7.1	Support analyzing data	L, P	AST	AST	AST	M	P, AST
Activity 7.2	Prepare federation VV&A products for reuse	AP	M	AST	P	L, P	

5.0 OVERLAY ASSUMPTIONS AND TAILORING

5.1 Assumptions

The following assumptions were made during development of the VV&A overlay to scope the responsibilities of the VV&A Team. They have been arranged loosely in logical, not priority, order:

- The Federation Development Team will follow the FEDEP in their development and execution of their federation.
- Coordination and cooperation between the VV&A Team and the Federation Development Team is essential.
- The Federation Development Team leads and performs federation verification activities.
- The VV&A Team leads and performs federation validation activities.
- Federate V&V information and use histories can provide valuable information for federation VV&A.
- The VV&A Team is not responsible for validating or verifying the individual federates although they do rely upon the products of these activities and may request or perform supplemental verification and validation to gain the information they need for federation VV&A.
- The VV&A Team will have timely access to the information they require.
- The User/Sponsor will agree that a finite set of observable or measurable acceptability criteria will be used to judge federation acceptability for an intended use.
- The VV&A processes may be executed iteratively throughout the federation development and execution process.
- All federations will be subject to an acceptance process that may or may not include accreditation.
- If needed, accreditation of the federation can occur anywhere from Activity 5.5 through Activity 7.1.
- The federation VV&A processes described in this overlay can and should be tailored to meet the needs of the individual applications.

5.2 Tailoring

The VV&A activities described in this document, while being generally applicable to most HLA federations, are intended to be tailored to meet the needs of each individual application. Every federation application is unique. The extent to which these VV&A processes can be performed for a given federation application will depend on a number of factors, including the quality of the requirements information and the resources allocated to the VV&A Team. The recommended practices provided in this document should be used as a starting point for developing the specific approach to federation VV&A needed to support the intended use.

Below are some perspectives on tailoring the VV&A processes to best fit the circumstances of each individual application.

- Tailoring is driven by risk and resource constraints (e.g., available information, budget, skills, time).
- Quantifying and minimizing risk are factors that drive tailoring decisions.
- The correctness and completeness of the federation VV&A products can reduce the risk incurred by using the federation results (i.e., use risk).

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- The absence of certain information input to the VV&A processes will limit the quality of the content of the VV&A products.
- Tailoring decisions have an impact upon use risk and the resources required, and this impact should be understood and documented.
- The VV&A processes should leverage testing and data collection tasks and describe this in the Federation Accreditation Plan and V&V Plan.
- Any tailoring should adhere to any existing policies, standards or guidelines that may be relevant to the intended use.
- Tailoring may be done at any time in the federation VV&A processes.

6.0 VV&A OVERLAY MODEL: TOP-LEVEL VIEW

As in the FEDEP, one of the design goals identified during the development of this VV&A overlay was to define a highly flexible process. This facilitates tailoring the VV&A activities defined in this overlay as the user needs and resource constraints demand. The actual application of VV&A techniques to support the development of a federation could vary significantly within or across different intended uses. However, the VV&A phases that correspond to the FEDEP steps establish a foundation for applying VV&A within the FEDEP. Figure A1-1 illustrates each of the FEDEP steps together with the corresponding VV&A overlay phases.

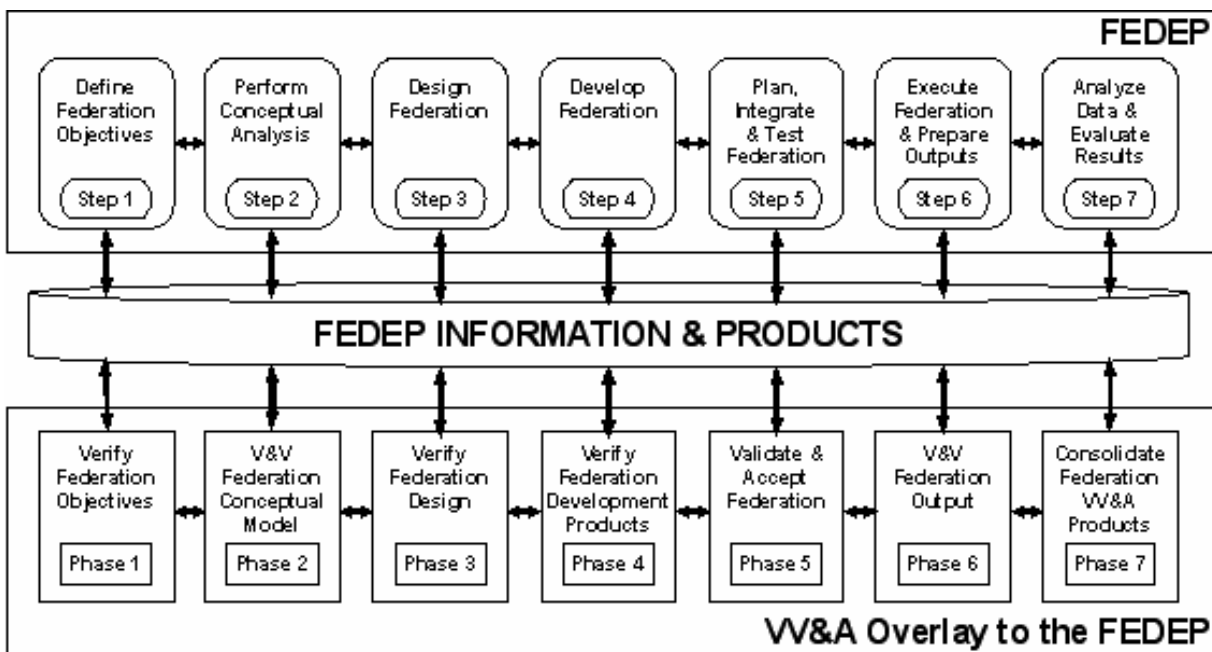


Figure A1-1: Top-Level View of the VV&A Overlay to the FEDEP.

The purpose for each of the overlay phases is summarized below:

- *Phase 1: Verify Federation Objectives* – The VV&A Team works as part of the Federation Development Team to define a set of Federation Objectives and verify the completeness, consistency,

and correctness of those objectives with the User/Sponsor. The VV&A Team also assembles the Federation Referent, defines the Federation Acceptability Criteria, and formulates the initial Federation Accreditation Plan and V&V Plan at this time.

- *Phase 2: V&V Federation Conceptual Model* – The VV&A Team supports the Federation Development Team in developing the Federation Scenarios, Federation Conceptual Model, and Federation Requirements. They also contribute to verifying these products and are responsible for validating the Federation Conceptual Model.
- *Phase 3: Verify Federation Design* – The VV&A Team supports selecting the federates and preparing the Federation Design. They also contribute to verifying the Federation Design and provide an updated Federation Accreditation Plan and V&V Plan for inclusion into the Federation Development and Execution Plan.
- *Phase 4: Verify Federation Development Products* – The VV&A Team supports developing the FOM, establishing the Federation Agreements, and implementing the Federation Infrastructure. They also contribute to verifying the FOM, Federation Agreements, and Federation Infrastructure. They provide any support needed to verify and validate the federate implementations and collect the information from these V&V processes. Finally, they verify and validate the data sets needed for federation execution.
- *Phase 5: Validate and Accept Federation* – The VV&A Team supports the Federation Development Team in planning the federation execution, integrating the federation, and testing the federation. They also contribute to verifying the integrated federation. They have primary responsibility for validating the results produced by the integrated federation and developing the federation acceptance/accreditation recommendations from the collected V&V evidence.
- *Phase 6: V&V Federation Output* – The VV&A Team supports executing the federation when needed and contributes to verifying the raw execution and derived output produced from these executions. They then validate the federation output when needed.
- *Phase 7: Consolidate Federation VV&A Products* – The VV&A Team supports analyzing the federation output when needed and collects and assembles the products from the preceding VV&A activities into a consolidated package to support future reuse.

The seven phases in this overlay parallel the seven steps in the FEDEP. As in the FEDEP, this overlay decomposes each of the VV&A phases into a set of interrelated lower-level activities and supporting information resources.

7.0 VV&A OVERLAY MODEL: DETAILED VIEW

The VV&A overlay describes a high level framework for verifying, validating, and accepting HLA federations. The intent of the VV&A overlay is to specify a recommended practice that details the VV&A phases that correspond to, support, and augment the FEDEP steps. Federation stakeholders can leverage this overlay to achieve the specific needs associated with their intended use.

Figure A1-2 provides a detailed view of the VV&A overlay and its interactions with the FEDEP at equivalent levels of abstraction. This view illustrates the flow of VV&A activities, information, and products across the seven process phases identified in Figure A1-1. Figure A1-2 depicts the FEDEP steps, the VV&A phases, and the VV&A information shared between these steps and phases.

APPENDIX 1 – VV&A OVERLAY TO THE FEDEP

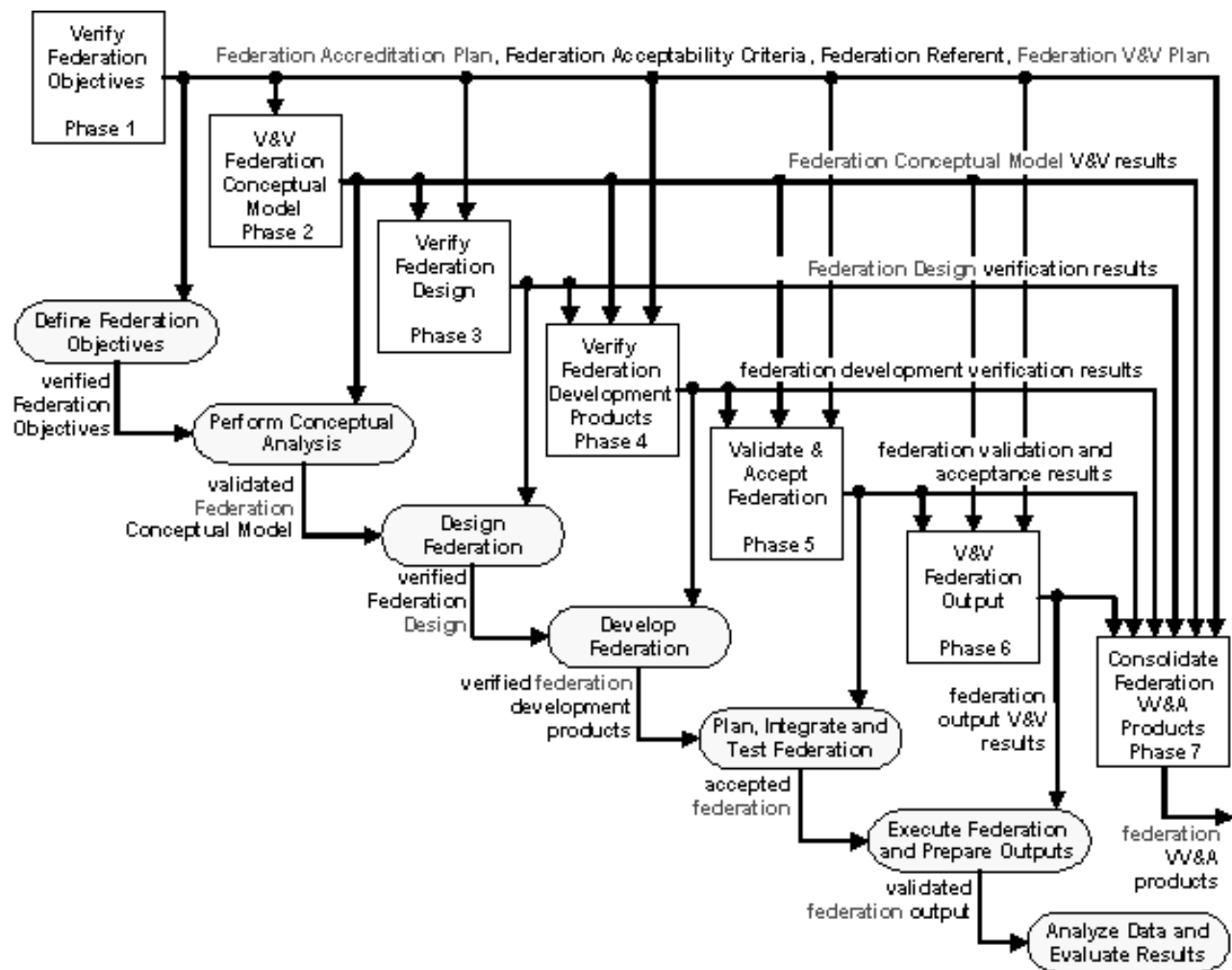


Figure A1-2: Detailed View of the VV&A Overlay to the FEDEP.

The following subsections describe the lower-level activities associated with each of the seven major VV&A phases associated with the FEDEP's seven steps. Figure A1-3 identifies the individual activities that compose each of these of these VV&A phases. Each activity description includes the information required, the component tasks, and the information produced for that activity. As in the FEDEP, this overlay assumes that once a product has been created, it will be available for all subsequent activities; even though the product may not be identified as an input in the activity description.

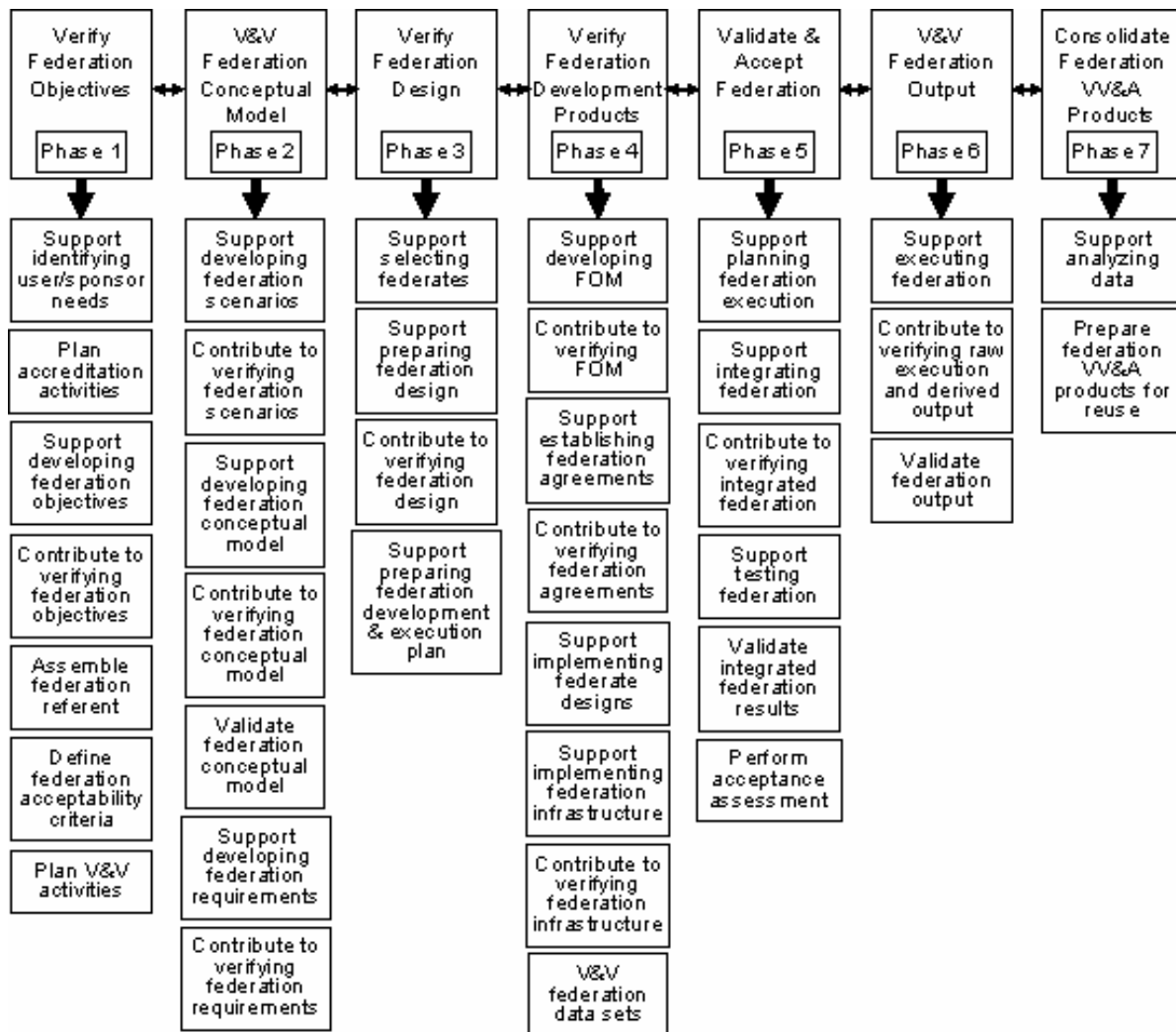


Figure A1-3: Activities Associated with Each VV&A Overlay Phase.

Although many of the activities represented in this overlay diagram appear highly sequential, the intention is not to suggest a strict waterfall approach to VV&A. Rather, this process illustration is simply intended to highlight the major VV&A activities that occur during federation development and execution and approximately when such activities are first initiated relative to other VV&A or FEDEP activities. The activities described in this recommended practice are intended to be tailored to meet the needs of each individual application. The guidance provided in this recommended practice should be used as a starting point for developing the specific approach to VV&A associated with federation development and execution for the intended use.

7.1 Phase 1 – Verify Federation Objectives

The purpose of Phase 1 of the VV&A overlay is to define the scope of the VV&A effort and establish a stable foundation for establishing a federation's validity. This requires the VV&A Team to understand the Federation Objectives, the risk that the User/Sponsor can tolerate in their intended use of the federation's output, the nature of the Federation Referent, the information needed to define realistic and observable Federation Acceptability

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Criteria, and the resources required to support the subsequent VV&A activities. This phase should result in a set of verified Federation Objectives and a Federation Referent and Federation Acceptability Criteria that adequately represent those objectives.

Figure A1-4 illustrates the key activities in this phase of the overlay. These activities support the Federation Development Team in identifying, clearly describing, and documenting the problem that the federation addresses. Understanding what the User/Sponsor really needs the federation to accomplish is essential to the development and VV&A of the federation. A clear, consistent, and complete yet concise User/Sponsor Needs statement will aid the VV&A Team in understanding and assessing the federation objectives, requirements, development plans, and other products resulting from exercising the FEDEP. For example, the User/Sponsor Needs statement should include such information as high level descriptions of the critical systems of interest, initial estimates of fidelity requirements, key scenario events, and output data requirements. These insights are important for early VV&A planning.

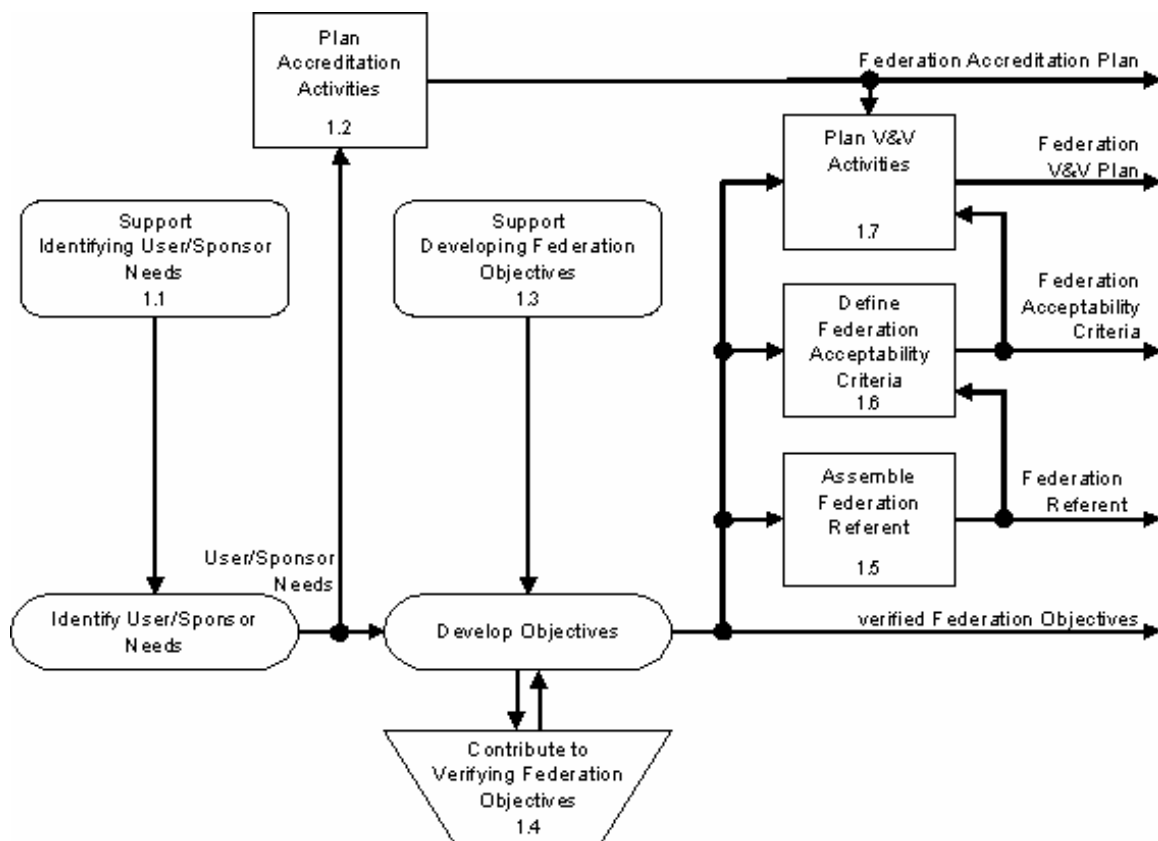


Figure A1-4: Verify Federation Objectives (Phase 1) Activity Diagram.

7.1.1 Activity 1.1 – Support Identifying User/Sponsor Needs

This activity assists the Federation Development Team in identifying, clearly describing, and documenting the problem that the federation addresses. Understanding what the User/Sponsor really wants the federation to accomplish is essential to the development and VV&A of the federation. A clear, consistent, and complete yet concise User/Sponsor Needs statement will aid the VV&A Team in understanding and assessing the

federation objectives, requirements, development plans, and other products resulting from exercising the FEDEP. For example, the User/Sponsor Needs statement should include such information as high level descriptions of the critical systems of interest, initial estimates of fidelity requirements, key scenario events, and output data requirements. These insights are important for early VV&A planning.

The Federation Development Team should ensure that the user's representational needs (i.e., what the federation needs to represent and how correct those representations need to be) are captured and understood in the course of this activity. In addition, the impact of federation use should be assessed and the User/Sponsor tolerances to risk should be estimated. As part of this assessment, the VV&A Team should identify, quantify using consistent units, and rank the User/Sponsor perceptions of the impact of the federation producing incorrect results. The VV&A Team should assemble the information on the impacts and risks of using a federation into the Federation Use Impact Assessment.

The process of identifying User/Sponsor Needs will provide insight into how correct the federation needs to be and how much detail the referent needs to provide. This information will help to identify the Federation Referent. The VV&A Team should also assess the credibility of any existing domain descriptions recommended by the User/Sponsor.

Finally, as part of the corresponding FEDEP activity the Federation Development Team begins to identify the resources that will be available to support the federation (e.g., personnel, tools, and facilities) as well as any known constraints that may affect how the federation is developed (e.g., required federation participants, due dates, site and federation management requirements, and security requirements). The VV&A Team can supply information to support this task. For example, they might have input to the selection of particular tools or facilities that would benefit both development and V&V activities.

7.1.1.1 Information Required

- Overall plans (from the User/Sponsor's perspective)
- Existing domain descriptions
- Information on available resources
- User/Sponsor needs input including program objectives

7.1.1.2 Functions (Tasks)

- Support analysis of the program objectives to identify the specific purpose and objective(s) that motivate development and execution of a federation
- Support identifying the available resources and known development and execution constraints, as appropriate
- Assess the User/Sponsor's belief in the credibility of the existing domain descriptions
- Identify, quantify using consistent units, where possible, and rank the User/Sponsor perceptions of the impact of using the federation
- Determine the User/Sponsor tolerances for risk of incurring the impacts of the federation producing incorrect results for their intended uses

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- Assemble the information on the impacts and risks of using a federation into the Federation Use Impact Assessment
- Support documentation of the User/Sponsor Needs

7.1.1.3 *Information Produced*

- Input to the detailed User/Sponsor Needs (e.g., analysis results, revision suggestions)
- Input to the available resources and known development and execution constraints
- Credibility of the existing domain descriptions
- Federation Use Impact Assessment

7.1.2 **Activity 1.2 – Plan Accreditation Activities**

This activity focuses on planning the federation accreditation activities. The resulting plan identifies the information required to support an acceptance decision and the tasks needed to develop that information. The Federation Accreditation Plan is necessary for planning the V&V activities, guiding the accreditation process, and building the Federation Development and Execution Plan.

An acceptance decision (i.e., a decision to use a federation's results to serve an intended use) precedes federation use. A formal accreditation decision follows when required. The accreditation activities, and the planning for them, support either formal accreditation or informal acceptance.

This activity analyzes the User/Sponsor Needs and the Federation Use Impact Assessment, as well as other information, to determine the needed accreditation tasks then organizes those tasks into an executable sequence. For example, the accreditation tasks might include formulating the acceptability criteria, constructing the referent, performing a risk assessment, and developing the federation acceptance/accreditation recommendations. The Federation Accreditation Plan also identifies the information that the V&V activities should produce. Finally, the accreditation tasks are arranged into a schedule and estimates of the resources needed to perform the accreditation are made.

This activity assumes that the User/Sponsor understands and has expressed their perspective on what they need for the federation to do, how correct it needs to be, and the process they intend to use to identify and assign resources to the accreditation and V&V processes. It also assumes that the User/Sponsor understands the impact and risk of applying the federation to their intended use.

7.1.2.1 *Information Required*

- User/Sponsor Needs
- Overall plans (from the User/Sponsor's perspective)
- Federation Use Impact Assessment
- Available resources and known development and execution constraints
- User/Sponsor input on the credibility expected of the federation results

7.1.2.2 Functions (Tasks)

- Derive and prioritize the acceptance/accreditation objectives considering the User/Sponsor credibility expectations, overall User/Sponsor's plans, User/Sponsor Needs, known resource constraints, and Federation Use Impact Assessment
- Identify the specific tasks needed to achieve each acceptance/accreditation objective
- Determine the information dependencies between each acceptance/accreditation tasks and organize the execution of these tasks based upon those dependencies
- Identify the specific V&V information needed to support the federation's acceptance/accreditation
- Determine the dependencies between the accreditation information needs and organize those needs accordingly
- Devise a preliminary schedule within which to execute the acceptance/accreditation tasks in the proper order
- Estimate the resources (e.g., time, funding, personnel, tools, federation development products, information) required to perform each V&V task
- Document an initial version of the Federation Accreditation Plan

7.1.2.3 Information Produced

- Initial Federation Accreditation Plan

7.1.3 Activity 1.3 – Support Developing Federation Objectives

This activity supports developing the Federation Objectives. The Federation Objectives serve as a foundation for generating Federation Requirements (i.e., translating high-level User/Sponsor expectations into more concrete, measurable federation goals).

This activity requires close collaboration between the federation User/Sponsor and the Federation Development Team, including the VV&A Team, to ensure that the original needs are properly analyzed and correctly interpreted and that the resulting objectives completely capture the nuances of the intended use.

The VV&A Team actively participates in the FEDEP tasks of:

- Analyzing sponsor needs with an emphasis upon those needs that have implications for the federation's representations
- Assessing federation feasibility and risk with the insight gained from the Federation Use Impact Assessment
- Contributing to documenting Federation Objectives
- Defining and documenting the initial Federation Development and Execution Plan
- Identifying the initial tools to support federation development that also support the VV&A activities
- Supporting the User/Sponsor review of the Federation Objectives and reconciling differences

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In addition, the VV&A Team should determine their impact upon the test, configuration management, security, and quality assurance plans, and provide input to those plans to reflect those impacts. For example, the V&V activities should collaborate closely with the testing efforts in order to leverage the testing activities for results validation. The VV&A Team should work with the testing team to ensure that the federation testing will generate the data necessary to support V&V activities. Similar cooperation is needed between the VV&A efforts and those for configuration management and quality assurance. Measures to assure the security of the federation and its information can impact the representational capabilities of the federation. The VV&A Team should review the security plans to ensure that the Federation Development Team is aware of any representational impacts of the planned security measures.

7.1.3.1 Information Required

- User/Sponsor Needs
- Existing domain descriptions
- Federation Use Impact Assessment
- Initial Federation Accreditation Plan
- Initial plans from the other Federation Development Team members (e.g., security, configuration management, testing)
- Information on the resources available for the federation VV&A activities

7.1.3.2 Functions (Tasks)

- Support analyzing the User/Sponsor Needs and deriving the Federation Objectives from those needs, particularly the representational objectives
- Support assessing the federation feasibility and risk, particularly the risk associated with the federation's use
- Support defining, prioritizing, and documenting the Federation Objectives
- Support defining and documenting the initial Federation Development and Execution Plan, particularly those aspects involving, affecting or affected by the VV&A activities
- Support identifying the potential tools to support federation design, development, and execution that also support the VV&A activities
- Determine and generate input to the test, configuration management, security, and quality assurance planning documents
- Support the User/Sponsor review of the Federation Objectives and reconciling differences

7.1.3.3 Information Produced

- Input to the Federation Objectives
- Input to the federation risk assessment
- Input to the initial Federation Development and Execution Plan
- Input to the test, configuration management, security, and quality assurance planning documents
- Input to the initial federation design, development, and execution tool selection

7.1.4 Activity 1.4 – Contribute to Verifying Federation Objectives

This activity determines that the Federation Objectives correctly and adequately represent the User/Sponsor Needs and may indicate the need for corrections or additions. An incomplete statement of Federation Objectives impacts the ability to meet the User/Sponsor Needs while overly broad Federation Objectives could unnecessarily tax the available resources.

Verifying the completeness and consistency of the Federation Objectives, addressing both their content and form, is essential to ensure that they provide a clear, solid, and unmistakable foundation for further federation development and use. Further, documenting the traceability between the Federation Objectives and the User/Sponsor Needs is essential to diagnosing any problems and making design and development tradeoff decisions.

The VV&A Team should approach verifying the Federation Objectives as an integral part of the Federation Development Team. The Federation Development Team members can successfully share the burden of verification in many different ways depending upon the specifics of the organizations involved, the distribution of responsibilities within that team, and the nature of the Federation Objectives.

Regardless of who performs specific verification tasks, the tasks in this activity assume that the VV&A Team has complete access to the results from all verification tasks as well as the Federation Objectives and the User/Sponsor Needs and can get clarifications from the User/Sponsor upon request.

7.1.4.1 Information Required

- User/Sponsor Needs
- Federation Objectives

7.1.4.2 Functions (Tasks)

- Check the Federation Objectives for internal consistency and completeness
- Verify the Federation Objectives against the User/Sponsor Needs and provide feedback on the results of that consistency check
- Contribute to documenting the Federation Objectives verification results
- Contribute to documenting the traceability between the Federation Objectives and the User/Sponsor Needs

7.1.4.3 Information Produced

- Federation Objectives verification results
- Information describing the traceability between the Federation Objectives and the User/Sponsor Needs

7.1.5 Activity 1.5 – Assemble Federation Referent

This activity assembles the referent that serves as the basis for assessing the correctness of the federation's representation. Referent knowledge can come from direct observations of the represented phenomena, validated theory describing the phenomena, validated simulations representing the phenomena, subject matter expert knowledge of the phenomena, and combinations of information from these different sources. In addition, it may

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come from several independent sources of the same type. The content of the Federation Referent depends upon the intended use of the federation and the contributing federate representations. Further, the Federation Referent need only cover those areas where one needs to judge the representation's correctness. The Federation Objectives can provide the information needed to tailor the referent's scope.

The tasks in this activity represent the effort required to:

- Collect the information from the different referent sources
- Combine that information into a single consistent referent for the entire federation's representation

Collecting the referent information includes defining the referent's scope of coverage, identifying credible sources, and acquiring the information from which the referent will be constructed. Information describing the same phenomena may need to be combined into a consistent description. That process involves selecting the combination or fusion techniques, actually exercising those techniques on the contributing information, and estimating the uncertainties associated with the integrated referent.

Federation Referents may be assembled from the referents used for the individual federates or some combination of information from federate referents and from external sources, then tailored to suit the scope defined by the Federation Objectives. When collecting referent information, descriptions of the uncertainties associated with that information should be collected at the same time where available. If not available then those uncertainties should be estimated where possible.

Above all, the Federation Referent should be credible to the User/Sponsor because they should be confident that the federation has sufficient correctness to serve their intended use. This constraint implies that the User/Sponsor should trust the credibility of the referent information sources, the techniques used to fuse that information into a single referent, and the people applying those fusion techniques. Often the User/Sponsor will have a specific referent source in mind (e.g., existing domain descriptions, training documents, legacy simulations). The VV&A Team needs to recognize these preferences and gain access to these sources to support Federation Referent construction.

7.1.5.1 Information Required

- Verified Federation Objectives
- User/Sponsor Needs
- User/sponsor suggestions for credible referent sources
- Federation Use Impact Assessment
- Initial Federation Accreditation Plan
- Existing domain descriptions
- Referents used for past federations with similar objectives

7.1.5.2 Functions (Tasks)

- Identify the referent needs from the Federation Objectives
- Select credible referent information sources
- Acquire referent information from the selected sources

- Choose referent information fusion techniques where needed
- Combine referent information from multiple sources into a coherent referent
- Estimate the error characteristics of the integrated Federation Referent, where possible
- Estimate the uncertainties associated with the errors in the Federation Referent, where possible
- Document the Federation Referent description

7.1.5.3 Information Produced

- Federation Referent.

7.1.6 Activity 1.6 – Define Federation Acceptability Criteria

Defining the Federation Acceptability Criteria should clearly and unmistakably outline the scope of the VV&A effort and establish a stable foundation for assessing a federation's validity. Federation Acceptability Criteria are derived from the Federation Objectives and are measurable criteria that explicitly define the limits of federation validity.

The Federation Acceptability Criteria should be necessary and sufficient to assess the federation's validity and acceptability for the intended use. They should be chosen so that passing all of them implies fitness for the intended use and failing any one of them requires the placing of limitations on the original intended use. While a general set of Federation Acceptability Criteria addresses a wide range of federation capabilities, those of primary interest to the VV&A team define the representational aspects of the federation, including:

- Output data (including visual and audio presentations) that the federation should generate
- Input data that the federation needs to accept, the ranges of values of those inputs over which the federation needs to generate valid output and the errors in that input (defined against the referent) that the federation needs to tolerate while still generating valid output
- Entities, the properties that represent the state of those entities, and the relationships between those entity properties that the federation needs to represent to generate valid output when provided sufficient input data
- Required parameters that can be controlled and varied during federation execution, including man-machine-interaction
- Minimum confidence required that each acceptability criterion has been met

This activity assumes that the User/Sponsor or their representative reviews the Federation Acceptability Criteria for completeness and correctness. The VV&A Team will likely define the Federation Acceptability Criteria iteratively, beginning with preliminary criteria then refining these as they gain more information through the federation development process. This activity produces an initial set of criteria that later activities will refine and extend.

7.1.6.1 Information Required

- Verified Federation Objectives
- Federation Referent
- Initial Federation Accreditation Plan

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- User/Sponsor Needs
- Federation Use Impact Assessment
- Relevant measures of effectiveness and measures of performance related to the required representational capabilities

7.1.6.2 *Functions (Tasks)*

- Derive and verify appropriate acceptability criteria from the User/Sponsor Needs, the Federation Objectives, and the Federation Referent
- Verify the internal consistency and completeness of the resulting acceptability criteria set
- Verify the completeness and correctness of the Federation Acceptability Criteria with the User/Sponsor Needs and Federation Objectives
- Verify the consistency of the acceptability criteria with the User/Sponsor's intent
- Contribute to documenting the traceability between the Federation Acceptability Criteria and the Federation Objectives
- Document the Federation Acceptability Criteria

7.1.6.3 *Information Produced*

- Initial Federation Acceptability Criteria
- Information describing the traceability between the Federation Acceptability Criteria and the Federation Objectives

7.1.7 **Activity 1.7 – Plan V&V Activities**

This activity plans the V&V effort to support the federation acceptance/accreditation recommendations. The Federation Acceptability Criteria scope this plan. Failure to carefully review the information to support this planning will place the successful completion of the V&V process at risk.

This activity involves identifying the V&V objectives from the accreditation information needs defined in the Federation Accreditation Plan and the Federation Acceptability Criteria, prioritizing those objectives, placing them in perspective with the User/Sponsor Needs (including the correctness required for the intended use), determining the specific tasks needed to achieve those objectives, and assigning resources to complete those tasks. Examples of these tasks include validating the conceptual model, verifying the Federation Object Model, and validating the federation results.

The VV&A Team needs to understand the Federation Objectives, the risk that the User/Sponsor can tolerate in their intended use of the federation's output, the information that the acceptance/accreditation process needs from the V&V process, and the planned resources available to support the V&V activities. If the VV&A Team believes more resources are required to perform the tasks then they should make the Federation Manager or User/Sponsor aware of that need.

This activity will produce an initial V&V plan that can then be refined as the VV&A Team gains information through the federation development process.

7.1.7.1 Information Required

- Initial Federation Accreditation Plan
- Initial Federation Acceptability Criteria
- Verified Federation Objectives
- User/Sponsor Needs
- User/Sponsor input as to the credibility expected of the federation results
- Overall plans (from the User/Sponsor's perspective)
- Initial Federation Development and Execution Plan
- Initial plans from the other Federation Development Team members (e.g., security, configuration management, testing)
- Federation Use Impact Assessment
- Available resources and known development and execution constraints

7.1.7.2 Functions (Tasks)

- Derive and prioritize V&V objectives from the acceptance/accreditation information needs, known resource constraints, Federation Use Impact Assessment, Federation Accreditation Plan, and other FEDEP planning documents
- Identify the specific tasks needed to achieve each V&V objective based on the most appropriate and cost-effective methods, tools, and techniques
- Determine the information dependencies between each V&V task and organize the execution of these tasks based upon those dependencies
- Devise a preliminary schedule within which to execute the V&V tasks in the proper order
- Estimate the resources (e.g., time, funding, personnel, tools, federation development products, information) required to perform each V&V task
- Identify candidate V&V tools
- Document the initial Federation V&V Plan based on the results of tasks above

7.1.7.3 Information Produced

- Initial Federation V&V Plan

7.2 Phase 2 – Verify and Validate Federation Conceptual Model

The primary purpose of Phase 2 of the VV&A overlay is to verify and validate the Federation Conceptual Model. The VV&A Team also supports developing and contributes to verifying the Federation Scenarios, Federation Conceptual Model, and Federation Requirements. These activities contribute to ensuring that a federation built to meet the Federation Requirements can fully realize the representational capabilities described in the validated Federation Conceptual Model and enables it to execute the Federation Scenarios.

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Development and verification of the Federation Scenarios and Federation Conceptual Model may be done in parallel and iteratively. Once this iteration process has produced a stable Federation Conceptual Model, the VV&A Team can validate it.

Figure A1-5 illustrates the key activities in this phase of the VV&A overlay. The subsections that follow describe each of these activities.

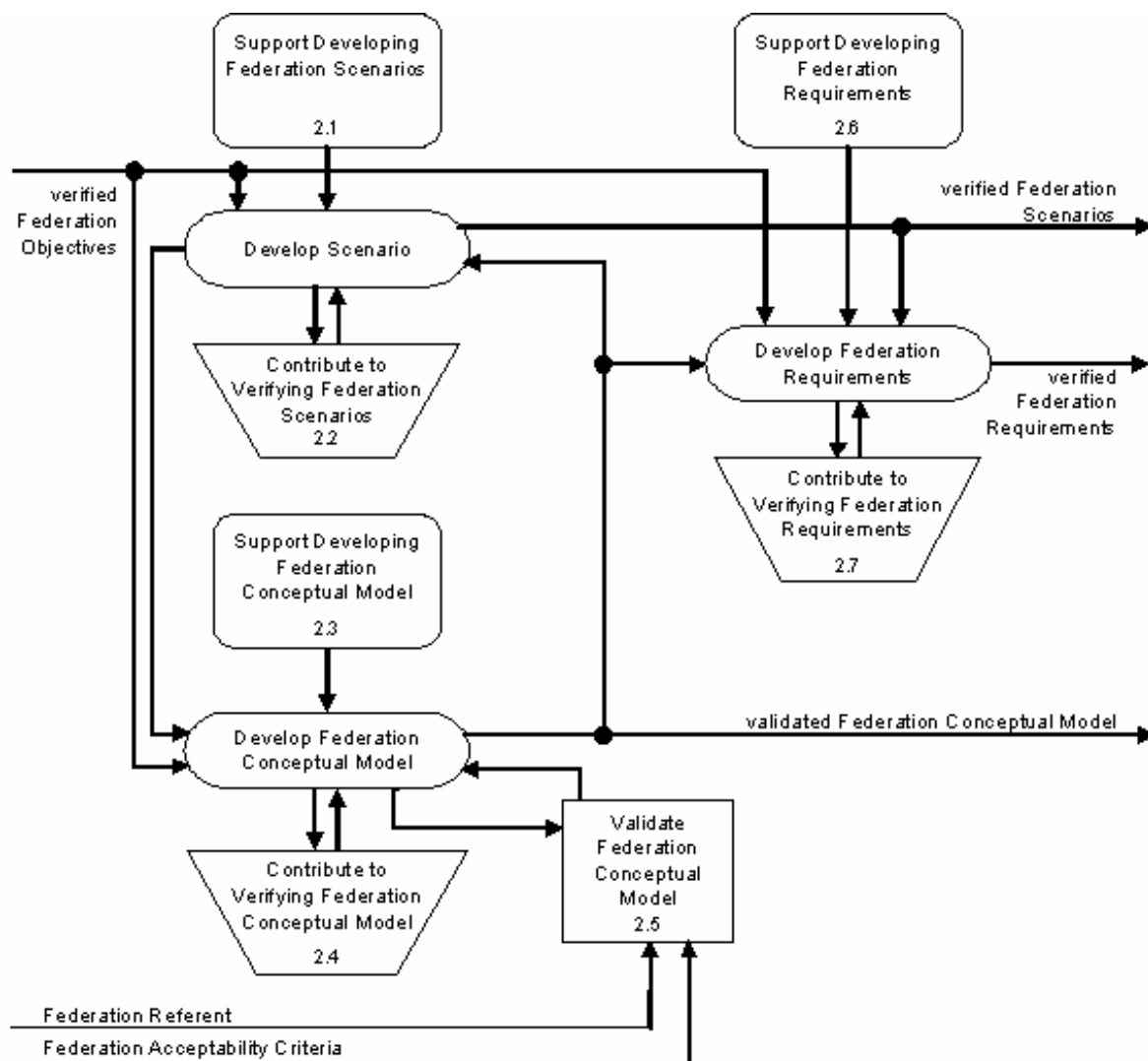


Figure A1-5: V&V Federation Conceptual Model (Phase 2) Activity Diagram.

7.2.1 Activity 2.1 – Support Developing Federation Scenarios

This activity supports producing a functional specification of the envisioned federation scenario. A Federation Scenario serves as a bounding mechanism on the scope of conceptual modeling activities. At a minimum, the Federation Scenario defines the initial and termination conditions for the federation execution in terms of the federation's representations.

A Federation Scenario should describe the types and numbers of major entities that should be represented in a federation; functional descriptions of their capabilities, behaviors, and relationships over time, and the relevant environmental conditions that influence the simulated entities.

The VV&A Team should ensure that the Federation Scenarios adequately meet the verified Federation Objectives and are credible to the User/Sponsor. To do this the VV&A Team should determine whether the proposed scenario development standards, tools, and techniques are suitable to support scenario verification activities. Related tasks for the VV&A Team would be to locate and collect V&V histories of the candidate scenarios, as well as to locate and collect information describing the pedigree of the existing domain descriptions. The VV&A supports the Federation Development Team in vignette definition.

This activity assumes that the VV&A Team has adequate access to the information supporting Federation Scenario development (e.g., authoritative data sources) to assess scenario credibility. This activity also assumes iterative interaction between the development of the Federation Scenario and the Federation Conceptual Model.

7.2.1.1 Information Required

- Verified Federation Objectives
- Existing scenarios
- Federation Conceptual Model
- Existing domain descriptions

7.2.1.2 Functions (Tasks)

- Determine the suitability of the planned scenario development standards, tools, and techniques to support scenario validation activities
- Locate and collect V&V histories of the candidate scenarios
- Evaluate the appropriateness of the existing scenario resources for achieving the Federation Objectives
- Locate and collect information describing the pedigree of the existing domain descriptions
- Contribute to validating the Federation Scenarios against the Federation Acceptability Criteria and the Federation Referent, as needed
- Evaluate the credibility and applicability of the domain descriptions for achieving the Federation Objectives
- Support defining one or more representative vignettes of federation events that, once executed, will produce the data necessary to achieve Federation Objectives

7.2.1.3 Information Produced

- Input to the Federation Scenarios

7.2.2 Activity 2.2 – Contribute to Verifying Federation Scenarios

The primary goals for verifying the Federation Scenarios are to demonstrate that they fully cover the verified Federation Objectives and, if required, to indicate the need for any corrective actions. The Federation

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Scenarios outline the simulation executions and if they do not fully cover the intended use then achieving the Federation Objectives could be endangered.

This activity should verify the internal consistency and completeness of the Federation Scenarios ensure that they are clearly, completely, and correctly documented, and make certain that they are traceable back to the Federation Objectives. Like the Federation Objectives, documenting the traceability of the Federation Scenarios links them to User/Sponsor Needs through the Federation Objectives. This traceability contributes to diagnosing any problems and making design and development tradeoff decisions.

Also as with the Federation Objectives, the VV&A Team should approach verifying the Federation Scenarios as an integral part of the Federation Development Team and expect to share the burden of verification in one of many different ways depending upon the specifics of the organizations involved, the distribution of responsibilities within that team, and the nature of the Federation Objectives.

Regardless of who performs specific verification tasks, this activity assumes that the VV&A Team has complete access to the results from all verification tasks as well as the Federation Scenarios. This activity also assumes that Federation Scenarios and Federation Conceptual Model are developed in concert over several iterations. Verification of the Federation Scenarios may also occur iteratively.

7.2.2.1 Information Required

- Verified Federation Objectives
- Federation Scenarios
- Federation V&V Plan

7.2.2.2 Functions (Tasks)

- Verify the internal consistency and completeness of the Federation Scenarios
- Verify the consistency of the Federation Scenarios with the Federation Objectives
- Contribute to documenting the Federation Scenarios verification results
- Contribute to documenting the traceability between the Federation Scenarios and the Federation Objectives

7.2.2.3 Information Produced

- Federation Scenarios verification results
- Information describing the traceability between the Federation Scenarios and the Federation Objectives

7.2.3 Activity 2.3 – Support Developing Federation Conceptual Model

This activity supports producing a Federation Conceptual Model. The Federation Conceptual Model is a conceptual representation of the intended problem space based upon the Federation Development Team's interpretation of the verified Federation Objectives. A Federation Conceptual Model provides an implementation-independent representation that serves as a vehicle for transforming Federation Objectives into functional and behavioral descriptions for system and software designers. The model also provides a crucial traceability link between the Federation Objectives and the Federation Design implementation.

The Federation Development Team, with input from the VV&A Team, has the discretion to choose the presentation style most useful for describing the entities and actions that need to be included in the federation in order to achieve all Federation Objectives. A Federation Conceptual Model needs to be carefully evaluated before continuing to the succeeding stages of federation development. At a minimum, the User/Sponsor should review key processes and events to ensure the adequacy of the conceptual representation.

The VV&A Team participates as part of the Federation Development Team from the initial specification of the Federation Conceptual Model through its evolution during subsequent federation development steps. They can assist Federation Development Team to determine whether or not existing conceptual models or domain descriptions should be used as the foundation for conceptual model construction based upon the Federation Objectives. The VV&A Team can also contribute to establishing the credibility of the Federation Conceptual Model by locating and collecting information describing the pedigrees of the domain descriptions and by explicitly identifying the underlying assumptions and limitations of the Federation Conceptual Model.

7.2.3.1 Information Required

- Verified Federation Objectives
- Existing domain descriptions
- Federation Scenarios
- Existing conceptual models

7.2.3.2 Functions (Tasks)

- Support choosing the technique and format for developing and documenting the Federation Conceptual Model in order to better support V&V activities
- Evaluate the applicability of existing conceptual models to the Federation Objectives
- Locate and collect information describing the pedigree of the authoritative domain descriptions used for conceptual model construction
- Evaluate the applicability of the domain descriptions to the Federation Objectives
- Contribute to identifying and documenting the assumptions and limitations associated with the Federation Conceptual Model

7.2.3.3 Information Produced

- Input to the Federation Conceptual Model
- Input to documentation of the assumptions and limitations underlying the Federation Conceptual Model

7.2.4 Activity 2.4 – Contribute to Verifying Federation Conceptual Model

This activity verifies the internal consistency, completeness, and correctness of the Federation Conceptual Model and its consistency with the verified Federation Objectives and the Federation Scenarios. This step assures that the representations defined in the Federation Conceptual Model are internally sound and can support the execution of the Federation Scenarios. This creates a firm foundation for conceptual model validation and the derivation of the Federation Requirements.

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This activity verifies that the Federation Conceptual Model contains the content defined in the FEDEP (e.g., entity state and behavior representations) in the form specified by the Federation Development Team. It also verifies the consistency of any diagrams depicting model structure and behavior, the correctness of the unit transformations in any mathematical expressions, and the Federation Conceptual Model's consistency with the Federation Scenarios. This activity documents the traceability between the Federation Conceptual Model and the Federation Scenarios and between the Federation Conceptual Model and the Federation Objectives.

This activity assumes that the Federation Scenarios and the Federation Conceptual Model can be developed in concert over several iterations. Verification of the Federation Conceptual Model may also be iterative.

As with the other verification activities, the VV&A Team should approach verifying the Federation Conceptual Model as an integral part of the Federation Development Team. The Federation Development Team members can successfully share the burden of verification in many different ways depending upon the specifics of the organizations involved, the distribution of responsibilities within that team, and the nature of the Federation Conceptual Model.

Regardless of who performs specific verification tasks, the tasks in this activity assume that the VV&A Team has complete access to the results from all verification tasks and can get clarifications from the User/Sponsor as needed.

7.2.4.1 *Information Required*

- Verified Federation Objectives
- Federation Scenarios
- Federation Conceptual Model
- Federation V&V Plan

7.2.4.2 *Functions (Tasks)*

- Verify the internal consistency and completeness of the Federation Conceptual Model
- Verify the consistency of the Federation Conceptual Model with the Federation Scenarios
- Contribute to documenting the Federation Conceptual Model verification results
- Contribute to documenting the traceability between the Federation Conceptual Model and the Federation Objectives

7.2.4.3 *Information Produced*

- Federation Conceptual Model verification results
- Information describing the traceability between the Federation Conceptual Model and the Federation Objectives

7.2.5 **Activity 2.5 – Validate Federation Conceptual Model**

The Federation Conceptual Model provides the first meaningful insight into the federation's validity. The Federation Conceptual Model defines the representations upon which all subsequent activities build.

All succeeding verification activities contribute evidence to the validation of the federation by checking the consistency of the Federation Development Team's intermediate products (i.e., short of the functioning integrated federation) against the validated conceptual model. None of those intermediate products can be considered valid unless the Federation Conceptual Model is valid.

At minimum, the tasks of this activity assess the completeness of the federation's representations, as defined in the verified Federation Conceptual Model, against the Federation Acceptability Criteria. If the Federation Conceptual Model contains sufficient detail then this activity also assesses its correctness against the Federation Acceptability Criteria. Finally, this activity should result in the User/Sponsor's approval of the Federation Conceptual Model. This task improves the likely relevance of the resulting federation to the User/Sponsor and contributes to the process of building federation credibility with those users.

The extent to which the VV&A Team can perform the recommended conceptual model validation tasks depends strongly upon the information contained in the Federation Objectives, the detail of the Federation Acceptability Criteria, the detail in the Federation Conceptual Model, and the resource limitations of the VV&A Team.

This activity assumes that the iteration within the "Perform Conceptual Analysis" step of the FEDEP has stabilized and produced a fairly representative conceptual model. Some federation development efforts may choose to perform iterative validation upon the Federation Conceptual Model while others may choose to wait until the end. An iterative approach may tailor the validation tasks for each iteration except at the end. This activity also assumes that the Federation Conceptual Model has been verified before being validated.

7.2.5.1 Information Required

- Verified Federation Conceptual Model
- Federation Acceptability Criteria
- Federation Referent
- Federation V&V Plan

7.2.5.2 Functions (Tasks)

- Evaluate the completeness of the Federation Conceptual Model against the Federation Acceptability Criteria and Federation Referent and identify areas of incompleteness
- Estimate the error characteristics of the Federation Conceptual Model, where possible
- Evaluate the correctness of the Federation Conceptual Model against the Federation Acceptability Criteria and Federation Referent and identify areas of incorrectness, where possible
- Document the Federation Conceptual Model validation results
- Support reviewing the contents of the Federation Conceptual Model with the User/Sponsor by reviewing the Federation Conceptual Model contents and the assembled validation evidence with them
- Get the approval of the User/Sponsor for the validated Federation Conceptual Model

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7.2.5.3 *Information Produced*

- Federation Conceptual Model validation results
 - Within the context of the Federation Referent, identification of the Federation Acceptability Criteria that the Federation Conceptual Model
 - Meets
 - Does not meet
- Characterization of the representational errors that exceed the Federation Acceptability Criteria limits, where possible
- User/Sponsor approval of the Federation Conceptual Model

7.2.6 **Activity 2.6 – Support Developing Federation Requirements**

This activity supports development of the Federation Requirements. The Federation Requirements are based upon the verified Federation Objectives, the verified Federation Scenarios, and the validated Federation Conceptual Model. This activity transforms the Federation Objectives into specific set of detailed and testable Federation Requirements that provide the implementation-level information needed to design and develop the federation. The VV&A Team should support the Federation Development Team to ensure that the Federation Requirements are clear, unique, and testable.

In the course of developing the Federation Requirements, it may prove necessary to refine the Federation Objectives. If so, the VV&A Team should determine the validity impacts of any modifications, revise the Federation Acceptability Criteria as needed to maintain consistency with the revised Federation Objectives, and gain User/Sponsor concurrence of any such revisions of the Federation Acceptability Criteria.

The VV&A Team actively participates, as part of the Federation Development Team, in the development and documentation of all Federation Requirements. They also identify the validity implications of requirements for the execution environment, time management, data distribution management, execution management, federation performance, and security to ensure consistency between the resulting Federation Requirements and the Federation Acceptability Criteria. The VV&A Team should contribute to deriving a set of Federation Test Criteria from the Federation Requirements that efficiently determine whether the federation meets the Federation Acceptability Criteria. They should also develop revisions and extensions to the Federation Acceptability Criteria to maintain consistency with the Federation Requirements and Federation Test Criteria.

7.2.6.1 *Information Required*

- Verified Federation Objectives
- Verified and validated Federation Conceptual Model
- Verified Federation Scenarios
- Federation Referent
- Initial Federation Acceptability Criteria

7.2.6.2 Functions (Tasks)

- Support defining the Federation Requirements for the representational aspects of the federation (i.e., those related to federation fidelity)
- Support defining the federation output requirements from the Federation Acceptability Criteria
- Analyze the requirements associated with the execution environment, time management, data distribution management, execution management, federation performance, and security to determine their impact on and consistency with the federation representational requirements
- Support ensuring that the Federation Requirements are clear, unique, and testable
- Contribute to deriving a set of Federation Test Criteria from the Federation Requirements that efficiently determine whether the federation meets the Federation Acceptability Criteria
- Develop revisions and extensions to the Federation Acceptability Criteria to maintain consistency with the Federation Requirements and Federation Test Criteria
- Support documenting all federation requirements

7.2.6.3 Information Produced

- Input to the Federation Requirements
- Input to the Federation Test Criteria
- Revised Federation Acceptability Criteria

7.2.7 Activity 2.7 – Contribute to Verifying Federation Requirements

This activity verifies the internal consistency, completeness, and correctness of the Federation Requirements both internally and against the validated Federation Conceptual Model and verified Federation Scenarios, and indicates the need for any corrective actions that might be necessary. This step ensures that a federation built to meet the Federation Requirements fully realizes the representational capabilities described in the validated Federation Conceptual Model and enables it to execute the Federation Scenarios. Inadequate Federation Requirements can result in a federation that cannot meet the Federation Objectives and unnecessary Federation Requirements needlessly increase the developmental effort.

This activity includes ensuring that the Federation Requirements consistently, completely, and correctly capture all technical requirements concerning hardware platforms, operating environments, infrastructure, administration tools, and other components needed to realize a fully functioning federation. This activity also documents the traceability between the Federation Requirements and the Federation Conceptual Model and Federation Scenarios.

This activity assumes that the Federation Requirements and Federation Conceptual Model may be developed in concert over several iterations. Thus, verification of the Federation Requirements may also be iterative.

As with the other verification activities, the VV&A Team should approach verifying the Federation Requirements as an integral part of the Federation Development Team. Regardless of who verifies the Federation Requirements, the tasks in this activity assume that the VV&A Team has complete access to all verification results.

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7.2.7.1 *Information Required*

- Verified Federation Objectives
- Federation Requirements
- Federation Test Criteria
- Federation Acceptability Criteria
- Federation V&V Plan

7.2.7.2 *Functions (Tasks)*

- Verify the internal consistency and completeness of the Federation Requirements
- Verify the consistency, completeness, and correctness of the Federation Requirements with the Federation Objectives and Federation Acceptability Criteria
- Verify the internal consistency and completeness of the Federation Test Criteria
- Verify the consistency, completeness, and correctness of the Federation Test Criteria with the Federation Requirements
- Contribute to documenting the Federation Requirements and Federation Test Criteria verification results
- Contribute to documenting the traceability between the Federation Requirements and the Federation Conceptual Model, the Federation Scenarios, and the Federation Acceptability Criteria
- Contribute to documenting the traceability between the Federation Test Criteria and the Federation Requirements

7.2.7.3 *Information Produced*

- Federation Requirements verification results
- Federation Test Criteria verification results
- Information describing the traceability between the Federation Requirements and the Federation Objectives and Federation Acceptability Criteria
- Information describing the traceability between the Federation Test Criteria and the Federation Requirements

7.3 Phase 3 – Verify Federation Design

The purpose of Phase 3 of the VV&A overlay is to support federation design. The VV&A Team supports all of the activities in Step 3 of the FEDEP. They assist with evaluating the abilities of the candidate federates to meet the Federation Acceptability Criteria, evaluate the effects of the federation design decisions upon federation validity and update the Federation Accreditation Plan and V&V Plan. They also contribute to verifying the Federation Design.

Figure A1-6 illustrates the key activities in this phase of the VV&A overlay. The subsections that follow describe each of these activities.

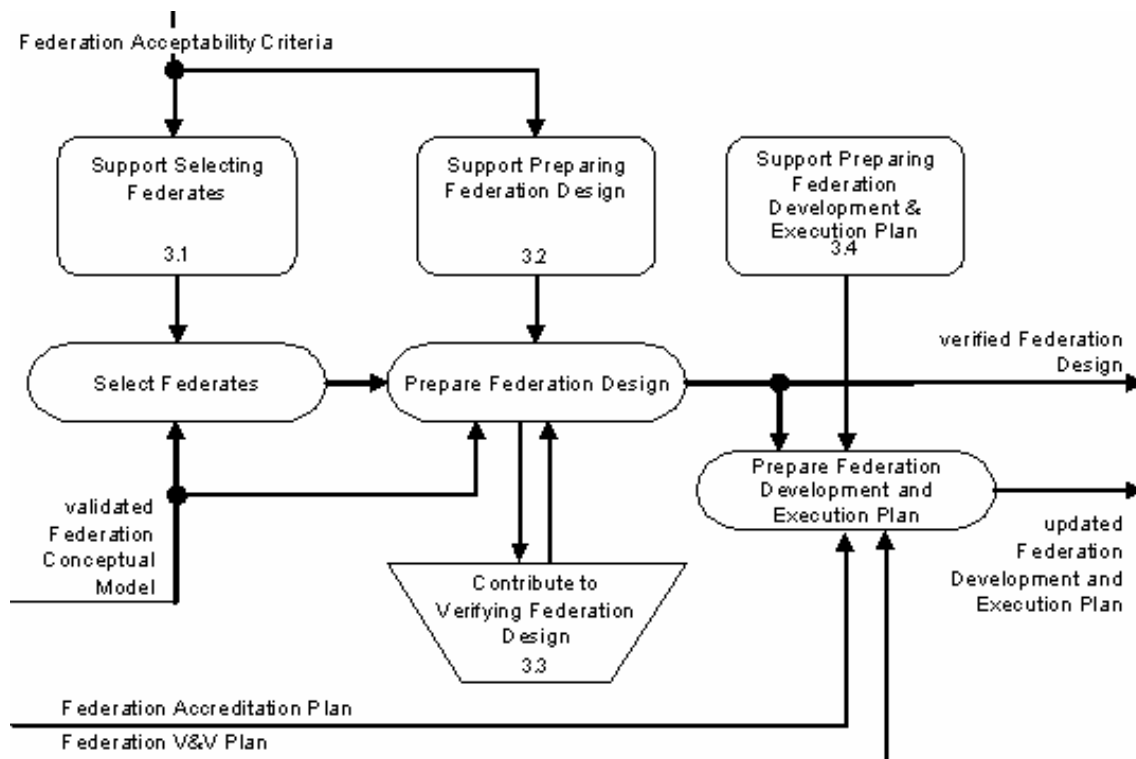


Figure A1-6: Verify Federation Design (Phase 3) Activity Diagram.

7.3.1 Activity 3.1 – Support Selecting Federates

In this activity, the VV&A Team supports the Federation Development Team in determining the suitability of individual simulation systems to become members of the federation being developed.

In order to select the most appropriate federates from the available candidates, federate selection criteria need to be defined based upon the validated Federation Conceptual Model, verified Federation Requirements, and the Federation Acceptability Criteria. These criteria should reflect the required entities/objects and events that the federates need to represent to achieve the Federation Objectives. Each candidate federate should be analyzed against these criteria to determine their ability to meet the Federation Acceptability Criteria and the rationale for those selected documented. The VV&A Team should assist the Federation Development Team in defining these federate selection criteria and using them to analyze candidate federates. In addition, if an existing federation is being considered for reuse in part or whole, the VV&A Team should assist in developing and applying similar criteria.

For each candidate federate or federation selected, the VV&A Team needs to collect any available V&V and use histories and evaluate them for quality and relevance to the Federation Acceptability Criteria. The quality and utility of this historical information available can vary greatly. The VV&A Team should evaluate the information made available and determine if additional V&V information is needed and recommend those information requirements to the Federation Development Team.

This activity assumes that the VV&A Team can readily access the V&V histories of all of the candidate federates as well as to the User/Sponsor to assess federate credibility.

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7.3.1.1 *Information Required*

- Federation Acceptability Criteria
- Verified Federation Objectives
- Verified Federation Requirements
- Federate documentation (including Simulation Object Models (SOMs))
- List of federate candidates
- Federate candidate V&V and use histories

7.3.1.2 *Functions (Tasks)*

- Support defining the criteria for federate selection from the Federation Acceptability Criteria
- Support determining if an existing reusable federation meets or partially meets the Federation Requirements
- Collect the available V&V and use histories for each federate candidate
- Evaluate the quality and relevance of this historical information to the Federation Acceptability Criteria
- Recommend additional V&V information requirements
- Support analyzing the ability of each federate candidate to meet the Federation Acceptability Criteria
- Support documenting the rationale for federate selection

7.3.1.3 *Information Produced*

- Input to the criteria for federate selection
- Input to candidate federate selection and selection rationale
- Recommendations of additional V&V information requirements

7.3.2 **Activity 3.2 – Support Preparing Federation Design**

In this activity, the VV&A Team supports the Federation Development Team in preparing the Federation Design. At this point, the responsibility to represent the entities and actions defined in the validated Federation Conceptual Model and Federation Scenarios has been allocated to candidate federates. Analysis of the selected federates is needed to identify those that can best provide the representational capabilities defined in the Federation Conceptual Model. As this analysis depends on the documentation of each candidate federate's capabilities, this is when any limitations of that documentation and any impacts those limitations might have on the design of the federation are determined. In addition, an assessment of whether the set of selected federates provides the required representational capabilities should be conducted. Federate modifications or the development of new federates may be required to realize the capabilities needed to meet the verified Federation Objectives.

When designing the federation, the Federation Development Team may need to negotiate agreements on assigned responsibilities or make various federation design decisions deemed appropriate based upon

investigations conducted. Such negotiations and trades may be required as technical issues such as time management, federation management, infrastructure design, runtime performance, and potential implementation approaches are considered in the design process. It is important that the VV&A Team ensure that these negotiations and design decisions are well documented and analyze them to determine the impact they will have upon the overall validity of the federation's representations.

The VV&A Team participates as part of the Federation Development Team in the federation design effort. In addition, they support the design effort by identifying the limitations of the existing federate candidate capabilities documentation and assessing the impact that those limitations will have on federation design effort.

This activity assumes that the VV&A Team can readily access the sources documenting the federate representational capabilities and all of the products from the federation design effort.

7.3.2.1 Information Required

- Federation Acceptability Criteria
- Verified and validated Federation Conceptual Model
- Verified Federation Scenarios
- Verified Federation Requirements
- Candidate federate documentation
- Federate candidate V&V and use histories

7.3.2.2 Functions (Tasks)

- Identify the limitations of the existing federate candidate capabilities documentation and assess the impact that those limitations will have on federation design activities
- Support analyzing the selected federates and identifying those federates that best provide the representational capabilities defined by the Federation Requirements and Federation Acceptability Criteria
- Support allocating the representational capabilities defined by the Federation Conceptual Model and Federation Scenarios to the selected federates and capture relevant information
- Determine the Federation Acceptability Criteria that each selected federate should support or contribute to supporting
- Decompose any requirement or acceptability criterion to which multiple federates contribute into requirements or acceptability criteria specific to the federate under consideration
- Contribute to determining if federate modifications or new federates are necessary

7.3.2.3 Information Produced

- Input to the Federation Design
- Suggestions for federate modifications or new federation development

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- Limitations of existing candidate federate documentation
- Assessment of the impact that inadequate federate documentation will have on federation validity and subsequent validation activities
- Allocation of the Federation Acceptability Criteria to the individual federates

7.3.3 Activity 3.3 – Contribute to Verifying Federation Design

This activity verifies the Federation Design, both internally and against the validated Federation Conceptual Model, to establish it as solid foundation for further federation development and, if required, to indicate the need for corrective actions. An inadequate Federation Design may, at best, delay realizing the federation and, at worst, lead to the development of a federation that cannot meet the verified Federation Objectives.

Verifying the consistency, completeness, and correctness of the Federation Design internally and against the Federation Conceptual Model is an integral part of the design effort. Design verification should ensure that the Federation Design represents all of the entities, entity attributes, relationships (both static and dynamic), behavioral and transformational aspects of the entities, and interactions between entities described in the Federation Conceptual Model. It should also consider the mapping of those representational features to the federates participating in the federation. Design verification may also analyze the expected frequencies of inter-federate communication to ensure that infrastructure loading conditions do not occur that can distort the federation's representational capabilities and cause validity problems.

As with the other verification activities, the VV&A Team should approach verifying the Federation Design as an integral part of the Federation Development Team and share the responsibilities for design verification as required by the specifics of the organizations involved and the delegations of responsibility within the Federation Development Team. Regardless of who performs the design verification tasks, the tasks in this activity assume that the VV&A Team has complete access to the design verification results. This activity further assumes that any design errors found during verification are reported to the Federation Development Team for timely and affordable correction.

7.3.3.1 Information Required

- Verified and validated Federation Conceptual Model
- Federation Design
- Federate documentation
- Federation Acceptability Criteria
- Federation V&V Plan

7.3.3.2 Functions (Tasks)

- Verify the mapping of the federate capabilities to the Federation Design
- Verify the internal consistency and completeness of the Federation Design
- Verify the consistency, completeness, and correctness of the Federation Design with the Federation Conceptual Model

- Verify that the Federation Design sufficiently satisfies the federation’s non-representational requirements
- Contribute to documenting the Federation Design verification results
- Contribute to documenting the traceability between the Federation Design and the Federation Conceptual Model

7.3.3.3 Information Produced

- Federation Design verification results
- Information describing the traceability between the Federation Design and the Federation Conceptual Model

7.3.4 Activity 3.4 – Support Preparing Federation Development and Execution Plan

This activity supports the Federation Development Team in preparing a coordinated plan to guide the activities for developing, integrating, testing, and executing the federation. This plan includes the plans for federation integration, test, and evaluation, configuration management, security, data collection, management, analysis, quality assurance, accreditation, and V&V as well as supporting tools selection and use. This planning activity will take place in concert with the development of the federation development and testing schedules that identify detailed tasks and milestones. A coordinated Federation Development and Execution Plan is essential to being able to successfully implement a federation that can achieve the Federation Objectives. This integrated planning effort requires close collaboration between all of the members of the Federation Development Team including the VV&A Team.

This coordinated set of plans covers areas critical to successful V&V of the federation. Therefore, the VV&A Team should understand and contribute to all aspects of the coordinated plan where the federation’s representations may be impacted. The VV&A Team should also examine the data collection, management, and analysis plans to ensure that their documentation is complete and conforms with other existing plans. In addition, the VV&A Team needs to develop a comprehensive results sampling strategy from the Federation Acceptability Criteria, Federation Conceptual Model, Federation Scenarios, and Federation Test Plan, and ensure that the test and evaluation and data collection plans adequately support this strategy. The VV&A Team should also revise the Federation Accreditation Plan and V&V Plan to reflect any revisions to the Federation Acceptability Criteria and to incorporate the results sampling strategy. Finally, the VV&A Team should determine that the tools they require are part of the tool selection and management plan as well as to ensure that the tools being considered for execution monitoring and control can support the V&V data collection needs.

7.3.4.1 Information Required

- Initial Federation Development and Execution Plan
- Initial Federation Accreditation Plan and V&V Plan
- Federation Acceptability Criteria
- Federation Referent
- Verified and validated Federation Conceptual Model

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- Verified Federation Design
- Verified Federation Scenarios
- Federation Test Plan
- Verified Federation Requirements
- Quality assurance, configuration management, data collection, management, and analysis plans
- Initial federation design, development, and execution tool selection

7.3.4.2 *Functions (Tasks)*

- Develop the federation results sampling strategy from the Federation Acceptability Criteria, Federation Conceptual Model, Federation Scenarios, and Federation Test Plan
- Update the Federation Accreditation Plan to reflect the revised Federation Acceptability Criteria
- Update the Federation V&V Plan to reflect the revised Federation Accreditation Plan and Test Plan, supporting tools and test strategies, and the federation results sampling strategy
- Contribute to updating the Federation Test Plan from the revised Federation V&V Plan
- Contribute input to quality assurance, configuration management, data collection, management, and analysis plans as needed
- Recommend tools and test strategies that could benefit the VV&A efforts and products
- Determine how the selected tools and test strategies impact VV&A activities
- Check that the tools identified for execution monitoring and control can support the planned federation results sampling strategy
- Support translating Federation Requirements into the federation execution and management plans

7.3.4.3 *Information Produced*

- Input to the Federation Development and Execution Plan
- Input to the Federation Test Plan revisions
- Input to the quality assurance, configuration management, data collection, management, and analysis plans as needed
- Input to the federation design, development, and execution tool selection
- Revised Federation Accreditation Plan and V&V Plan

7.4 Phase 4 – Verify Federation Development Products

The purpose of this phase in the overlay is to support the federation's development. This begins by supporting the development of and contributing to verifying the FOM, Federation Agreements, and Federation

Infrastructure. The federation VV&A Team also supports verifying and validating the federate implementations when needed and collects the information produced by these efforts. Finally, this phase includes the activities to verify and validate the data sets needed for the federation's execution.

Figure A1-7 illustrates the key activities in this phase of the VV&A overlay. The subsections that follow describe each of these activities.

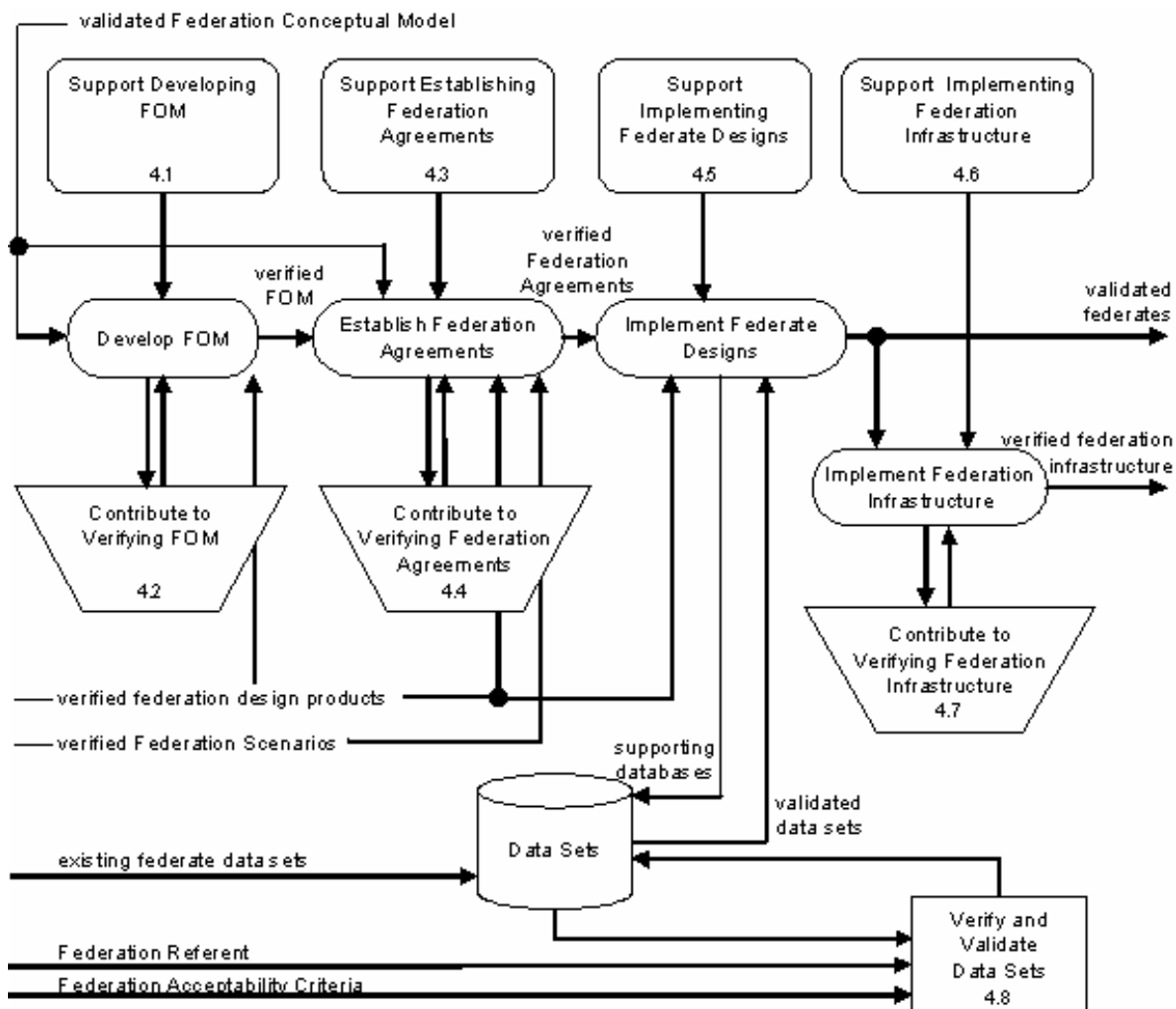


Figure A1-7: Verify Federation Development Products (Phase 4) Activity Diagram.

7.4.1 Activity 4.1 – Support Developing Federation Object Model

This activity supports the development of the FOM. The FOM defines the characteristics of those data exchanges needed to occur between participating Federates to meet the Federation Objectives. The goal of FOM development is to unambiguously assign the responsibilities for representing the entities, actions, and interactions of the Federation Conceptual Model to the assembled group of federates.

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No single “best” way to develop a FOM exists. Several different approaches have been used and all have their advantages and disadvantages. The choice of which FOM development approach to use depends upon the circumstances of the individual federation, and the preferences of the Federation Development Team. The VV&A Team supports the Federation Development Team by analyzing the chosen approach to determine the impact of that approach on the planned VV&A processes and the acceptability of the federation for the intended use.

The VV&A Team participates as part of the Federation Development Team in the FOM development effort by assisting in the review of existing object models or data dictionaries to identify reusable object models, or object model elements, and by assisting in the selection of a tool or tools to capture and document the FOM. They also ensure that the strategy used to allocate the responsibility to provide parts of the federation representations to individual federates does not adversely impact the federation’s validity. Finally, the VV&A Team should document the assumptions and limitations made during the FOM development process. To accomplish this task the VV&A Team will require access to the products generated by the FOM development effort.

7.4.1.1 *Information Required*

- Verified and validated Federation Conceptual Model
- Verified Federation Design
- Existing Federate SOMs
- Federation Development and Execution Plan
- Existing FOM if one exists or is being reused as a starting point
- Supporting resources (e.g., object model development tools, object model libraries, dictionaries)
- FOM development notes/agreements (e.g., conceptual model/scenario to FOM mapping, federate role/responsibility mapping, SOM-to-FOM mapping)

7.4.1.2 *Functions (Tasks)*

- Support choosing a FOM development approach and determine the implications of that choice upon subsequent VV&A
- Support identifying appropriate object models or object model subsets for reuse
- Support reviewing applicable data dictionaries to identify relevant object model elements
- Assist in selecting an appropriate tool for capturing and documenting the FOM
- Participate in the FOM design to ensure that the representation allocation strategy does not adversely impact the federation’s validity
- Contribute to documenting the limitations and assumptions of the FOM

7.4.1.3 *Information Produced*

- Contributions to the FOM development effort
- Contributions to documentation of the FOM limitations and assumptions

7.4.2 Activity 4.2 – Contribute to Verifying Federation Object Model

This activity verifies the FOM against the verified Federation Design, the validated Federation Conceptual Model, and the abilities of the individual federates to share information, and, if required, indicates the need for corrective actions. Any information exchanges required by the Federation Design or needed to represent the phenomena defined in the Federation Conceptual Model that are not reflected in the FOM suggest missing objects or interactions. An incomplete FOM may limit the federation's ability to achieve the federation objectives documented in the Federation Objectives Statement. FOM verification also adds an important link in the traceability chain.

As with the other verification activities, the VV&A Team should approach verifying the FOM as an integral part of the Federation Development Team and share this responsibility as required by the specifics of the organizations involved and the delegations of responsibility. Regardless of who performs the FOM verification tasks, the tasks in this activity assume that the VV&A Team has complete access to the FOM verification results. This activity assumes that verifying the FOM can be automated to some degree.

7.4.2.1 Information Required

- FOM
- Verified and validated Federation Conceptual Model
- Verified Federation Design
- Verified Federation Scenarios
- Federation V&V Plan

7.4.2.2 Functions (Tasks)

- Verify the internal consistency and completeness of the FOM
- Verify the consistency, completeness, and correctness of the FOM against the Federation Design, Federation Conceptual Model, and Federation Scenarios
- Contribute to documenting the FOM verification results
- Contribute to documenting the traceability between the FOM, the Federation Conceptual Model, and Federation Design

7.4.2.3 Information Produced

- FOM verification results
- Information describing the traceability between the FOM and the Federation Conceptual Model and Federation Design

7.4.3 Activity 4.3 – Support Establishing Federation Agreements

This activity supports the Federation Development Team in establishing the Federation Agreements. Federation Agreements are ad hoc agreements between Federation Development Team members that are necessary to achieve a fully consistent, interoperable, distributed federation. Federation Agreements are made

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to resolve federation operational design and execution management issues. Potential topics for Federation Agreements include federation operational procedures necessitated by federation selective use of interface standard services, federate use of common databases and algorithms, or federation and federate strategies for data collection. The Federation Development Team is responsible for explicitly considering what additional agreements are required and how those agreements should be documented. As part of this activity, the VV&A Team can make recommendations for agreements that impact the interoperability between the federates' representations.

The VV&A Team participates as part of the Federation Development Team to assess how the proposed Federation Agreements could affect the federation's validity. In this role, they should carefully examine each agreement to determine its impact upon the federation's representational capabilities and the federation's ability to meet the Federation Acceptability Criteria. The VV&A Team should ensure that the agreements to support interoperability between the federates' representations are negotiated and documented. To accomplish this, the VV&A Team will require access to all of the Federation Agreements created during the federation development.

In addition, the VV&A Team may need to establish agreements of their own to govern planned VV&A processes.

7.4.3.1 *Information Required*

- Verified FOM
- Verified Federation Scenarios
- Verified and validated Federation Conceptual Model
- Verified Federation Design
- Federation Development and Execution Plan
- Federation Acceptability Criteria
- Federation Development Team informal documentation (e.g., notes and agreements)

7.4.3.2 *Functions (Tasks)*

- Support the following FEDEP tasks:
 - Deciding the behavior of all federation objects and how they should interact during execution (to maintain validity)
 - Identifying the necessary software modifications to selected federates to assure federation validity
 - Deciding which databases and algorithms should be common or consistent in order to maintain sufficient interoperability
 - Identifying authoritative data sources for federate and federation databases and checking their pedigrees
 - Deciding how time should be managed in the federation in order to maintain validity
 - Establishing synchronization points for the federation and the procedures for federation initiation to assure federation validity during operation

- Deciding the strategy for how the federation shall be saved and restored in order to maintain sufficiently valid continuity
- Deciding how data is to be distributed to and collected from across the federation
- Transforming the functional scenario descriptions to executable scenarios
- Reviewing security agreements and procedures to ensure that these procedures do not adversely impact validity or, at least, to make the development team aware of impacts upon validity
- Ensure that agreements to support interoperability between the federates' representations are negotiated and documented

7.4.3.3 Information Produced

- Input to the Federation Agreements
- Input to the Federation Scenario instances

7.4.4 Activity 4.4 – Contribute to Verifying Federation Agreements

This activity verifies the consistency, completeness, and correctness of the Federation Agreements both internally and against the verified FOM, the verified Federation Design, the validated Federation Conceptual Model, and the verified Federation Scenarios. This verification process demonstrates that all interoperability issues critical for information sharing and compatibility of the selected federates not covered in the FOM are addressed and indicates the need for corrective actions that may be required.

Special care should be taken to establish agreements to ensure the consistency of internal federate representations (e.g., coordinate systems, line-of-sight calculations) within the federation, but that are not explicitly represented in the FOM, the Federation Design or the verified Federation Requirements. The absence of important Federation Agreements can significantly distort combined federation representations. This activity also documents the traceability between the Federation Agreements and the Federation Design, the Federation Requirements, the Federation Conceptual Model, and the Federation Scenarios.

As with the other verification activities, the VV&A Team should approach verifying the Federation Agreements as an integral part of the Federation Development Team and share this responsibility as required by the specifics of the organizations involved and the delegations of responsibility. Regardless of who performs Federation Agreement verification, the tasks in this activity assume that the VV&A Team has complete access to the Federation Agreement verification results. In addition, this activity assumes that the Federation Agreements are clearly and unmistakably documented.

7.4.4.1 Information Required

- Federation Agreements
- Verified Federation Scenarios
- Verified and validated Federation Conceptual Model
- Verified Federation Design
- Verified FOM
- Federation V&V Plan

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7.4.4.2 *Functions (Tasks)*

- Verify the internal consistency and completeness of the Federation Agreements
- Verify Federation Agreement consistency with the FOM, Federation Design, Federation Conceptual Model, and Federation Scenarios
- Contribute to documenting the Federation Agreements verification results
- Contribute to documenting the traceability between the Federation Agreements and the Federation Conceptual Model and Federation Design

7.4.4.3 *Information Produced*

- Federation Agreements verification results
- Information describing the traceability between the Federation Agreements and the Federation Conceptual Model and Federation Design

7.4.5 **Activity 4.5 – Support Implementing Federate Designs**

This activity supports the V&V activities associated with implementing the designs of the individual federates and modifying existing federates so they can comply with the Federation Conceptual Model, the FOM, and the Federation Agreements. The federation VV&A Team cooperates with the V&V teams supporting the individual federate design, development, and modification efforts to ensure that new or modified federates are verified and validated as needed to support the Federation Objectives. The federation VV&A Team must also ensure that traceability links between the individual federate designs and the Federation Design and Federation Requirements exist.

The federation VV&A Team recommends the V&V information requirements to the federate V&V teams. The federation VV&A Team then collects and integrates the results that these V&V activities produce. Information and associated documentation not provided by the federate V&V teams adds to the uncertainty associated with the federation's validation.

This activity assumes that a close cooperative relationship exists between the federation VV&A Team and the members of the V&V teams associated with the individual federates. Under some circumstances, the federation VV&A Team may need to take a more active role in federate verification and validation, but the available resources may limit the extent of this level of participation. This may range from simply monitoring to actually performing detailed testing on the individual federate.

7.4.5.1 *Information Required*

- Verified Federation Design
- Verified Federation Agreements
- Verified and validated Federation Conceptual Model
- Verified Federation Scenarios
- Verified FOM

- Verified Federation Requirements
- Federation Acceptability Criteria
- Federate V&V information

7.4.5.2 Functions (Tasks)

- Collect and integrate the historical and newly produced V&V information describing each federate's validated representational capabilities
- Recommend V&V information requirements for new or modified federates
- Contribute to verifying the mapping of new or modified federate capabilities to the Federation Design, as needed
- Contribute to the other verification activities for each new or modified federate, as needed
- Contribute to validating the federates against the Federation Acceptability Criteria and the Federation Referent, as needed
- Contribute to documenting the traceability between each federate and the Federation Design, Federation Scenarios, Federation Conceptual Model, Federation Agreements, FOM, Federation Requirements, and Federation Acceptability Criteria

7.4.5.3 Information Produced

- Integrated historical and newly produced V&V information for each federate
- V&V information requirements for new or modified federates
- Input supporting federate verification activities, as needed
- Input supporting federate validation activities, as needed
- Information describing the federate traceability, as needed

7.4.6 Activity 4.6 – Support Implementing Federation Infrastructure

In this activity, the VV&A Team supports the Federation Development Team in implementing, configuring, and initializing the infrastructure necessary to realize the federation and ensure that that infrastructure can support the execution and intercommunication of all of the federates. This involves implementing the network design (e.g., wide-area networks and local-area networks), initializing and configuring the network elements (e.g., routers and bridges), and installing and configuring the supporting software on all computer systems. All of these tasks are necessary to produce a successfully operating federation.

A federation's infrastructure can affect the validity of its representations in numerous ways. Therefore, the VV&A Team should participate as part of the Federation Development Team in implementing those aspects of the federation infrastructure that could affect the federation's validity. In this role, they should check that the federation's infrastructure functions sufficiently well to ensure the federation's validity. Further, the infrastructure (e.g., runtime infrastructure) initialization data may also be able to influence federation's representational capabilities. As a result, the VV&A Team should assure that this data does not

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adversely affect federation’s validity. The FEDEP states, “... extensive modification to the RTI initialization data are generally unnecessary, and should only be undertaken with sufficient knowledge of their potential impacts on the federation as a whole, minor modifications can improve federation performance in some circumstances.” Thus, the VV&A Team should ensure that any modifications to the infrastructure initialization data do not adversely affect the validity of the federation as a whole.

This activity assumes that the VV&A Team can readily access all of the information describing the characteristics of the federation’s infrastructure.

7.4.6.1 *Information Required*

- Federation infrastructure documentation (implementation and configuration management plan; initialization plan, host/platform information tables, network information tables, etc.)
- Verified Federation Agreements
- Verified Federation Design
- Verified FOM
- Federation Development and Execution Plan
- Federation Acceptability Criteria

7.4.6.2 *Functions (Tasks)*

- Assist in determining that the planned infrastructure design, configuration, and initialization will not adversely affect the ability of the federation to meet the representational requirements defined by the Federation Acceptability Criteria

7.4.6.3 *Information Produced*

- Input to the implemented federation infrastructure design

7.4.7 **Activity 4.7 – Contribute to Verifying Federation Infrastructure**

This activity verifies the consistency, completeness, and correctness of the federation infrastructure both internally and against the verified Federation Agreements and verified Federation Design.

This verification activity demonstrates that the infrastructure supports the information sharing and exchange among the federates needed to meet the Federation Requirements and suggests the need for any corrective actions. If the federation infrastructure cannot provide the needed quality of service to support the federate interactions then the federation’s validity may be compromised so that it cannot achieve the Federation Objectives.

As with the other verification activities, the VV&A Team should approach verifying the federation infrastructure as an integral part of the Federation Development Team and share this responsibility as required by the specifics of the organizations involved and the delegations of responsibility. Regardless of who verifies the federation infrastructure, the tasks in this activity assume that the VV&A Team has complete access to the infrastructure verification results.

7.4.7.1 Information Required

- Federation infrastructure documentation (implementation and configuration management plan; initialization plan, host/platform information tables, network information tables, etc.)
- Federation infrastructure design
- Verified Federation Agreements
- Verified Federation Design
- Verified FOM
- Federation Development and Execution Plan
- Federation Acceptability Criteria

7.4.7.2 Functions (Tasks)

- Participate in verifying that the federation infrastructure design and implementation are consistent with the Federation Design and development plans and will meet the documented infrastructure requirements
- Contribute to verifying that correct configuration, initialization, and operation of the infrastructure has been achieved
- Contribute to verifying that all federates have properly adhered to the infrastructure requirements and associated configurations and initializations
- Contribute to verifying that the implemented infrastructure supports the execution and intercommunication of the federates
- Contribute to documenting the federation infrastructure design results
- Contribute to documenting the traceability between federation infrastructure design and the Federation Design, FOM, and the Federation Agreements
- Observe infrastructure testing done by the Federation Development Team
- Determine if the infrastructure design, implementation, configuration, and initialization have affected the ability of the federation to meet the Federation Acceptability Criteria

7.4.7.3 Information Produced

- Federation infrastructure design verification results
- Information describing the traceability between federation infrastructure design and the FOM, Federation Design and Federation Agreements
- Observations of the federation infrastructure testing
- Determination of how the infrastructure design and implementation affect the federation's representational characteristics

7.4.8 Activity 4.8 – Verify and Validate Federation Data Sets

A federation uses a combination of data sets, each created for a specific purpose. Some data sets are used by individual federates. Two or more federates may share data or common databases while other data sets pertain

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to the entire federation execution. Finally, data may have been created to fill voids in available databases or to support federation testing. Regardless of whether federates and data sets have been used together in previous federations, some data set verification and validation will be necessary. The amount will depend upon the Federation Objectives, the acceptable risk, and the quality of the history available on each of the federates, and the data sets that they need. Any new data generated for the federation should be validated.

Data verification and validation are necessary at the federation level to ensure that the selected data sets have been obtained from appropriate sources, they are sufficiently correct to support the intended use, and the federates can meaningfully use them. This means that the data contained by those data sets have correct units of measure, have values within the federate input limits, are internally consistent, and are measured within the coordinate systems employed within the federates or are converted, as necessary. If a federation data model was constructed as part of Federation Design, it should be compared to the data set characteristics to assure the completeness of those data sets and their consistency with the Federation Design.

As with the other verification activities, the VV&A Team should approach verifying the federation data sets as an integral part of the Federation Development Team and share this responsibility as required by the specifics of the organizations involved and the delegations of responsibility. Regardless of who verifies the federation data sets, the tasks in this activity assume that the VV&A Team has complete access to the data set verification results. This activity also assumes that data set validation precedes federation validation. Testing should be conducted during federation construction and assembly to take advantage of ongoing federate compatibility tests.

7.4.8.1 *Information Required*

- Federation Acceptability Criteria
- Federation Referent
- Federation data sets and their metadata descriptions
- Federation data set histories
- Federation data set use restrictions
- Federation Design
- Federate algorithm descriptions
- Federation V&V Plan

7.4.8.2 *Functions (Tasks)*

- Verify data set sources to ensure the data and database sources are the most appropriate available
- Verify that federates are capable of exchanging data and sharing the databases as specified in the Federation Design
- Verify that the federate algorithms consistently support transformation and aggregation of the common data sets
- Compare key source data and metadata to federate input values and specifications to verify values assigned

- Identify differences in format or content of the key source data and metadata
- Assess the impact of any discovered discrepancies upon federation execution and output
- Contribute to documenting the traceability of inputs through applied transformations to ensure that the data have appropriate values and are handled consistently
- Compare the data sets to the Federation Acceptability Criteria to ensure the data selected are the data desired
- Ensure that the data needed are available and data voids and deficiencies are identified
- Validate data sets against applicable Federation Acceptability Criteria
- Conduct sensitivity analyses to assess the impact of data variations on the output results
- Assess the impacts and risks associated with inconsistent, incomplete, or incorrect data sets and make recommendations for reducing those risks
- Document the results of data set verification and validation

7.4.8.3 Information Produced

- Federation data set validation results
- Federation data set verification results
- Information describing the traceability between the federation data sets, their sources, and their transformations within the federates
- Data variation sensitivity analysis results
- Data set incompleteness and incorrectness risk assessment

7.5 Phase 5 – Validate and Accept Federation

The primary purpose of Phase 5 of the VV&A overlay is to validate and accept the federation for its intended use. This phase begins by supporting the execution planning in order to assure that the testing process will provide sufficient results to enable validating the integrated federation. The VV&A team also supports the federation integration activities of the FEDEP as needed and contributes to verifying the integrated federation. Additionally, they support federation testing and use the results from that testing to validate the integrated federation. The results from all of these and all previous V&V activities supply the evidence upon which to base the federation acceptance/accreditation recommendations.

Figure A1-8 illustrates the key activities in this phase of the VV&A overlay. The subsections that follow describe each of these activities.

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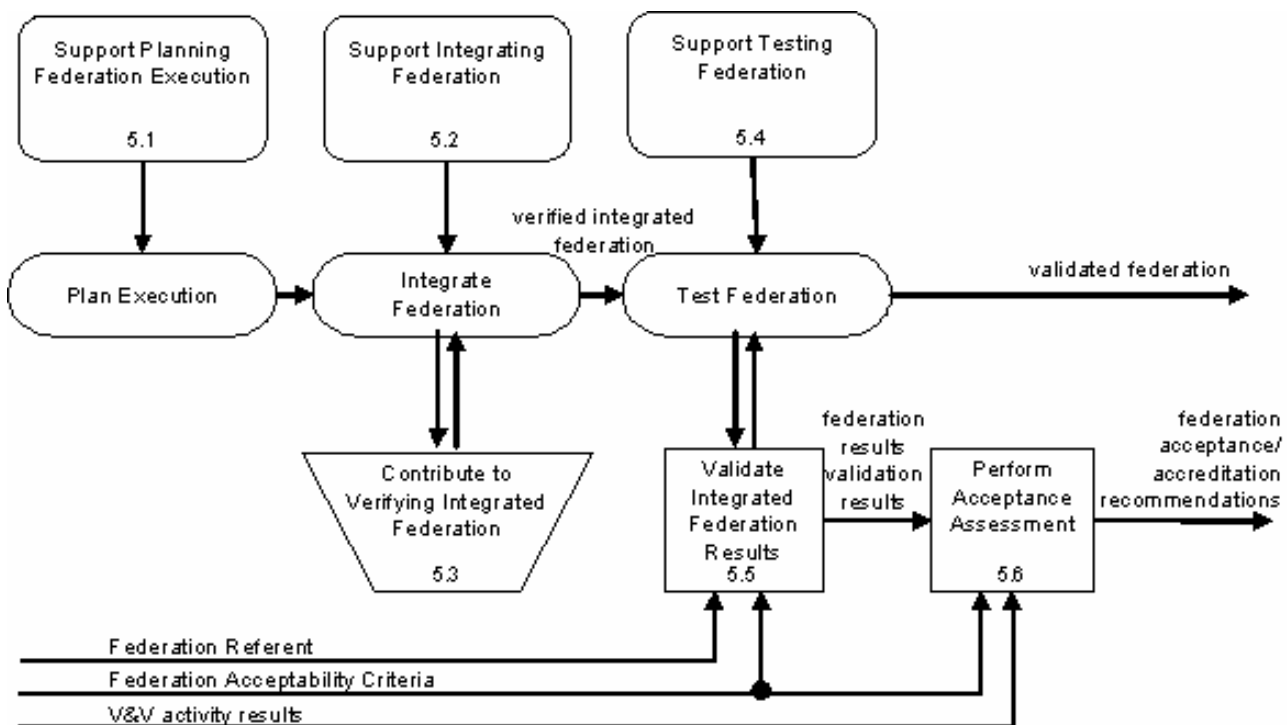


Figure A1-8: Validate and Accept Federation (Phase 5) Activity Diagram.

7.5.1 Activity 5.1 – Support Planning Federation Execution

In this activity, the VV&A team supports the Federation Development Team in planning of the federation's execution. This final planning activity involves several tasks that could impact the federation's representations. For example, the procedures for interrupting and restarting the federation execution could affect the federation's representation of causality and that could change the validity of the execution's results. The VV&A Team should work within the Federation Development Team to minimize the impact of any execution planning decisions upon the execution's validity.

This planning activity refines and augments the Federation Development and Execution Plan. The VV&A Team should identify the impacts that these changes could have upon the federation's validity and suggest modifications that could minimize these impacts where possible. The VV&A Team may also need to refine the Federation Accreditation Plan and V&V Plan to accommodate these changes and to incorporate any additional information gathered. Further, the VV&A Team should participate as part of the Federation Development Team in identifying risks and the actions needed to ameliorate them.

The VV&A Team should provide any additional inputs to the Federation Development and Execution Plan and its subordinate test and data collection plans that ensure that the data they need for results validation will be collected under the execution conditions described by the results sampling strategy and design of experiments. The VV&A Team should exploit all of the executions as much as possible to optimize the results collected.

This activity assumes that the VV&A Team has access to all of the information supporting the development and modification of the Federation Development and Execution Plan.

7.5.1.1 Information Required

- Verified FOM
- FOM Document Data/Federation Execution Data
- Federation Scenario instances
- Verified Federation Agreements
- Federation Development and Execution Plan
- Federation Accreditation Plan and V&V Plan

7.5.1.2 Functions (Tasks)

- Support identifying risks and the actions to address them
- Support documenting all of the information relevant to the federation execution
- Support developing detailed execution plans especially those relevant to collecting data to support federation results validation (e.g., testing and data collection) and those that might affect federation validity (e.g., security)
- Assess the effects that the special procedures for starting, stopping, and controlling each execution have on the validity of the federation execution and document these effects
- Refine the Federation Accreditation Plan and V&V Plan and provide these modifications to the Federation Development and Execution Plan
- Evaluate the impacts that other modifications to the Federation Development and Execution Plan may have upon federation validity (e.g., security plan) and provide this as feedback to the Federation Development Team

7.5.1.3 Information Produced

- Input to federation risk management activities
- Input to federation execution documentation
- Input to the Federation Execution Environment Description
- Revised Federation Accreditation Plan and V&V Plan
- Modifications to the Federation Development and Execution Plan due to Federation Accreditation Plan and V&V Plan revisions
- Evaluations of the impact of changes to the Federation Development and Execution Plan that could impact federation validity

7.5.2 Activity 5.2 – Support Integrating Federation

In this activity, the VV&A Team supports the Federation Development Team in integrating the federation to assure that the integration process results in valid federation representations. This may involve monitoring the

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federation integration process and observing that the Federation Development and Execution Plan is followed, particularly those parts that could impact the federation's validity.

The Federation Development Team may encounter and resolve problems during integration. The VV&A Team should determine the impacts that these problem resolutions have upon the federation's representations and their ability to meet the Federation Acceptability Criteria. This will help to avoid workarounds that adversely affect federation validity and will improve the likelihood of producing a valid federation for the users.

This activity assumes that the VV&A Team has complete access to all aspects of the federation integration process.

7.5.2.1 *Information Required*

- Federation Development and Execution Plan
- Verified federation development products
- Federation Execution Environment Description
- Verified and validated Federation Conceptual Model
- Verified Federation Design
- Verified Federation Agreements
- Verified FOM
- Runtime infrastructure initialization data
- Verified and validated federates (existing selected, modified, newly developed federates)
- Implemented and verified federation infrastructure design
- Verified and validated supporting data sets

7.5.2.2 *Functions (Tasks)*

- Determine the impact of the methods for managing known hardware, interface, and software problems and the “workarounds” to overcome them upon federation validity
- Determine the impact of deviations from the Federation Development and Execution Plan, particularly those aspects that could affect federation validity
- Monitor the conduct of the federation integration process

7.5.2.3 *Information Produced*

- Assessment of the impact of hardware, interface, and software problems and their workarounds upon federation validity
- Assessment of the impact of deviations from the Federation Development and Execution Plan upon federation validity

7.5.3 Activity 5.3 – Contribute to Verifying Integrated Federation

This activity verifies the consistency, completeness, and correctness of the integrated federation both internally and against the verified Federation Agreements, the verified Federation Design, and the validated Federation Conceptual Model.

This verification activity demonstrates that both the federates and the integrated federation function as designed and as needed to meet the Federation Requirements. For example, this activity should verify that all attribute updates and interactions are sent and received from source to destination as designed. In addition, the assertions, pre- and post-conditions as well as behavior constraints described in the Federation Design should be verified. This verification activity should also assess whether the federate hosts can communicate with each other and whether the network capacity and resulting communications latency meets the design specification. Failure to conform to the federate or federation design specifications suggests that the federation cannot meet the Federation Acceptability Criteria. This situation indicates the need for any corrective actions.

As with the other verification activities, the VV&A Team should approach verifying the integrated federation as part of the Federation Development Team and share this responsibility as required by the specifics of the organizations involved and the delegations of responsibility.

Regardless of who verifies the federation infrastructure, the tasks in this activity assume that the VV&A Team has complete access to the infrastructure verification results. This activity also assumes that tools for monitoring federation traffic are available.

7.5.3.1 Information Required

- Verified Federation Design
- Verified FOM
- Verified and validated Federation Conceptual Model
- Verified Federation Agreements
- Integrated federation
- Verified Federation Test Criteria
- Federation V&V Plan

7.5.3.2 Functions (Tasks)

- Contribute to verifying that the federation behaves according to the Federation Design
- Contribute to verifying that the integrated federation as a whole behaves according to the FOM, Federation Conceptual Model, and Federation Agreements
- Contribute to verifying that adequate communication exists to support valid federation operation
- Verify that federation tests adhered to the Federation Test Plan
- Contribute to documenting the integrated federation verification results
- Contribute to documenting the traceability between the integrated federation and the Federation Design, FOM, and the Federation Agreements

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7.5.3.3 *Information Produced*

- Integrated federation verification results
- Input on whether the federation tests adhered to the Federation Test Plan
- Information describing the traceability between the integrated federation and the FOM, Federation Design, and Federation Agreements

7.5.4 **Activity 5.4 – Support Testing Federation**

In this activity, the VV&A Team supports the Federation Development Team in testing the federation. All of the phases of this federation testing can supply data that is critical to results validation. Thus, the VV&A Team needs to participate in the testing to understand the actual test conditions in order to correctly interpret the test data for federation validation.

The VV&A Team should ensure that testing produces the data as defined in the test and data collection plans and that the test data is stored in an accessible form. They should also determine the impacts that any corrective actions planned by the Federation Development Team have upon the federation's validity. This information may identify the need to change these corrective action or modify the Federation Scenarios, Federation Objectives or Federation Acceptability Criteria. The VV&A Team should modify the Federation Accreditation Plan and V&V Plan to reflect these changes.

This activity assumes that the VV&A Team has access to all of the data produced by the federation testing tasks and that the testing tasks execute the test and data collection plans so as to produce sufficient data for results validation.

7.5.4.1 *Information Required*

- Verified integrated federation
- Federation Development and Execution Plan
- Verified Federation Agreements
- Federation Execution Environment Description
- Verified Federation Test Criteria
- HLA Federate Interface Specification, Framework and Rules, and Object Model Template Specification

7.5.4.2 *Functions (Tasks)*

- Support federate-level testing
- Support federation-level and interoperability testing
- Observe federation testing activities and collect data from these activities needed to support federation results validation

7.5.4.3 Information Produced

- Input to federate and federation testing
- Federation testing results to support federation results validation
- Data and observations collected during federation testing

7.5.5 Activity 5.5 – Validate Integrated Federation Results

Results validation is the pinnacle of the federation validation effort. Results validation assesses by checking the validity of the actual federation output against the Federation Acceptability Criteria. While results validation is only one piece of federation validation evidence, it often has the most credibility with the User/Sponsor.

Federation results validation builds upon the federation testing efforts and may require additional federation executions to augment the federation testing results. The results sampling strategy determines the need for these added executions as well as the required content from the tests. This activity should also determine the error characteristics and uncertainties associated with the sampled data and the results from any additional executions. This activity ends by inferring the root causes of any unacceptable results. This unacceptability may come from either federation behavior or the testing instrumentation and conditions. In either case, these causes are fed back to the Federation Development Team for correction. This feedback may result in additional testing which can then supplement the validation results.

This activity assumes that those responsible for testing the federation actually perform all executions and collect the results from those executions. This activity also assumes that the VV&A Team also evaluates those results to develop the evidence to support federation acceptance. Further, this activity assumes that a results sampling strategy has been formulated that can provide sufficient results to achieve the desired confidence in the validation evidence, that the test plan has incorporated that strategy, and that the plan has been faithfully executed. It also assumes that the federation results provided as input to results validation come from a correctly executing integrated federation and can be considered as representative of the results that the actual federation User/Sponsor will see.

7.5.5.1 Information Required

- Federation Acceptability Criteria
- Federation Referent
- Federation testing results
- Functioning integrated federation together with sufficient data to perform the validation executions
- Federation V&V Plan

7.5.5.2 Functions (Tasks)

- Identify executions needed to supplement those performed in integration testing in order to execute the federation results sampling strategy
- Perform any supplemental federation executions necessary

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- Collect federation execution results data and correlate them into a integrated picture of federation representational behavior
- Estimate the uncertainties associated with the correlated federation results sample
- Evaluate the completeness of the federation results against the Federation Acceptability Criteria and Federation Referent and identify areas of incompleteness
- Estimate the error characteristics of the correlated federation results
- Evaluate the correctness of the correlated federation results against the Federation Acceptability Criteria and Federation Referent and identify areas of incorrectness
- Estimate the uncertainties associated with the errors in the federation results
- Identify any observed interoperability anomalies and infer their probable causes
- Document the results of the federation results validation tasks

7.5.5.3 *Information Produced*

- Federation results validation results
 - Within the context of the Federation Referent, identification of the Federation Acceptability Criteria that the federation results
 - Meets
 - Do not meet
- Characterization of the representational errors in the federation results that exceed the Federation Acceptability Criteria limits
- Estimates of uncertainties associated with the representational errors in the federation results
- Observed interoperability anomalies and their probable causes

7.5.6 **Activity 5.6 – Perform Acceptance Assessment**

This activity results in recommendations on the conditions under which the federation results can serve the User/Sponsor Needs. These recommendations guide the User/Sponsor's acceptance of the integrated federation for their intended uses.

In this activity, the VV&A Team collects and aggregates all of the V&V evidence and derives from this evidence the federation acceptance/accreditation recommendations. The aggregation process should draw integrated assessments from disparate V&V results. For example, one piece of evidence may come from a subject matter expert's opinion while another may come from a statistical comparison test. The means to deal with these differences depend completely upon the characteristics of the evidence and the specific nature of the Federation Acceptability Criteria.

The VV&A Team should determine the degree to which the federation's capabilities meet the Federation Acceptability Criteria. This determination should identify the use conditions under which the federation meets

the Federation Acceptability Criteria. It should also identify those criteria that the federation cannot meet under any conditions of use. The Federation Development Team can deal with unmet acceptability criteria in many ways including revising the Federation Scenarios, modifying the federates or their databases, or modifying the Federation Objectives, thus changing the federation's intended use. Some of these solutions may require revisiting parts of the federation development process and its associated VV&A activities.

The FEDEP suggests that the federation testing activity should result in an integrated, tested, validated, and if required, accredited federation. This activity only accounts for the VV&A Team's support for producing an integrated and tested federation. Verification, validation, and acceptance of the integrated federation are all described under separate subsequent activities.

The recommendations from the acceptance assessment may lead to an accreditation decision that may be issued at any time following this acceptance assessment.

7.5.6.1 Information Required

- Documentation of the V&V activities and their results
- Federation Acceptability Criteria
- Federation V&V Plan
- Federation Accreditation Plan
- Federation Impact Use Assessment
- FEDEP products, necessary to interpret the conducted V&V-activities, e.g., Federation Objectives, Federation Test Criteria, Federation Development and Execution Plan
- Federation test results

7.5.6.2 Functions (Tasks)

- Determine that the V&V activities adhered to the constraints of the Federation V&V Plan
- Gather and aggregate the information produced by the V&V activities during the preceding parts of the federation development and execution process
- Evaluate and merge the V&V results
- Estimate the uncertainties associated with the merged V&V evidence
- Estimate the risks associated with using the federation to support the User/Sponsor Needs from the impacts described in the Federation Impact Use Assessment and the uncertainties associated with the merged V&V evidence
- Determine the recommended conditions of federation use in the context of the User/Sponsor Needs
- Document the recommended conditions of federation use and their rationale

7.5.6.3 Information Produced

- Federation acceptance/accreditation recommendations

7.6 Phase 6 – Verify and Validate Federation Output

Phase 6 of the VV&A overlay supports federation execution and monitors and documents the occurrence of any execution problems that may affect federation validity. These problems may be identified through verification of the raw execution and derived output or validation of the derived output.

Figure A1-9 illustrates the key activities in this phase of the VV&A overlay. The subsections that follow describe each of these activities.

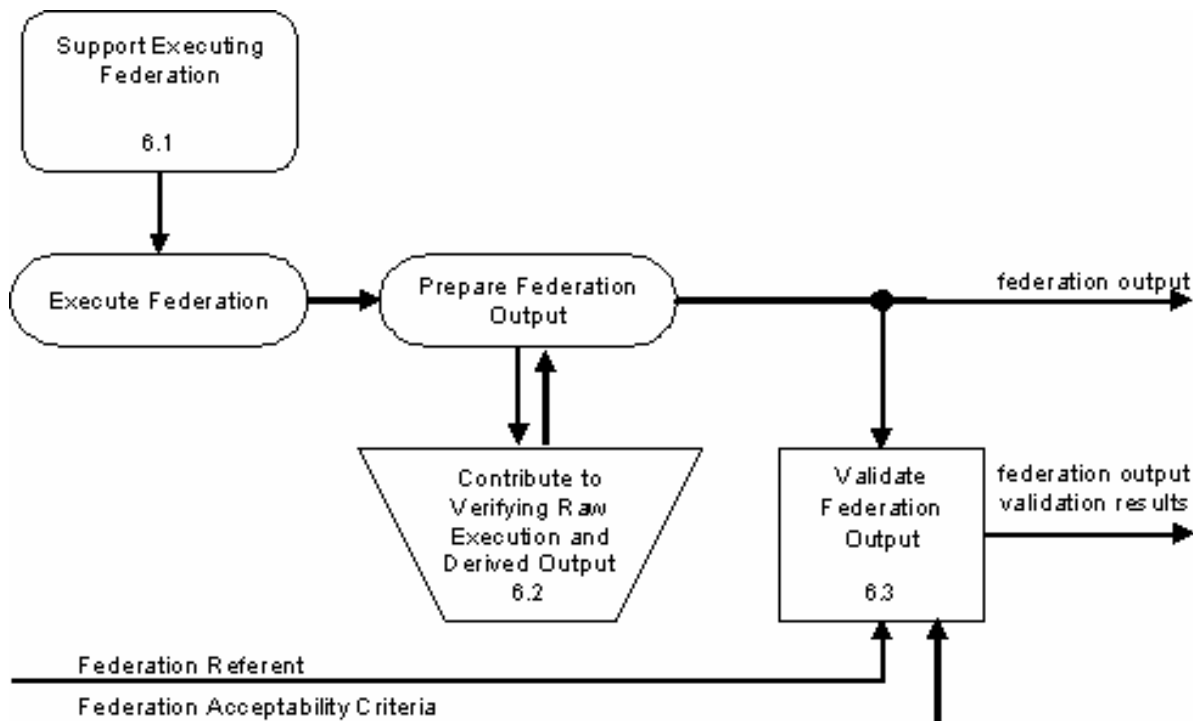


Figure A1-9: V&V Federation Output (Phase 6) Activity Diagram.

7.6.1 Activity 6.1 – Support Executing Federation

During this activity, the VV&A Team should monitor that the various aspects of federation execution conform to the Federation Development and Execution Plan and that any occurrences of execution problems that effect federation validity are identified and recorded.

Federation executions should be monitored to determine how well the Federation Acceptability Criteria are met in order to provide immediate feedback on the execution of the federation. If the VV&A Team has not completely validated the federation by this phase, additional data should be collected to further assess the validity of the federation. If new scenario instances or input data are introduced at this stage, the VV&A Team should assess the significance of those changes and provide feedback on the validity implications. These additions to the federation may require returning to the previous FEDEP and overlay steps.

If federation execution problems occur, the VV&A Team should assess the impacts of these problems and their workarounds, if any, upon the validity of the federation's results. They may need to suggest additional

constraints upon federation use to maintain the execution results validity. This activity assumes that some personnel from the VV&A Team continue to be involved in the federation execution and use in the later steps of the FEDEP.

7.6.1.1 Information Required

- Validated and accepted integrated federation
- Federation Development and Execution Plan
- Verified Federation Scenarios
- Federation scenario instances
- Verified Federation Agreements
- Federation Execution Environment Description
- Federation input data
- Supporting databases
- Federation Acceptability Criteria
- Federation acceptance/accreditation recommendations

7.6.1.2 Functions (Tasks)

- Monitor that the federation execution conforms to the Federation Development and Execution Plan, Federation Scenarios, Federation Execution Environment Description, and Federation Agreements
- Identify the occurrence of execution problems that impact the validity of the federation execution results

7.6.1.3 Information Produced

- Identification of any execution excursions outside the federation acceptance/accreditation recommendations
- Inputs to the documented execution problems

7.6.2 Activity 6.2 – Contribute to Verifying Raw Execution and Derived Output

This activity contributes to verifying the raw data collected during the federation execution and the output derived from this data in accordance with the V&V Plan and the Federation Development and Execution Plan. This includes an assessment of any data transformation or pre-processing algorithms or techniques that have been used. In addition, any incomplete, inconsistent, incorrect or erroneous output should be identified and corrective action taken where necessary.

During this activity, quality assurance/quality management tasks may be ongoing. If so, the VV&A Team should collect their information and use it to support this activity.

This activity assumes that some personnel from the VV&A Team continue to be involved in the federation execution and use in the later steps of the FEDEP and that any verification techniques used conform to the V&V Plan.

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7.6.2.1 *Information Required*

- Raw execution output
- Derived federation output
- Federation Development and Execution Plan

7.6.2.2 *Functions (Tasks)*

- Verify that the raw execution output conforms to data collection plan that is part of the Federation Development and Execution Plan
- Verify, with the users, that the data formats and transformations of the federation output are appropriate and applied within their constraints
- Identify, with the user, missing and erroneous output
- Contribute to documenting the raw execution output and derived federation output verification results

7.6.2.3 *Information Produced*

- Raw execution output verification results
- Derived federation output verification results
- Information on any missing or erroneous output

7.6.3 **Activity 6.3 – Validate Federation Output**

This activity validates, against the Federation Acceptability Criteria and the Federation Referent, the completeness and correctness of the derived output data collected during the federation execution prior to its formal analysis. Any areas of incompleteness or incorrectness should be documented and reported to the User/Sponsor and the Federation Development Team together with the uncertainties associated with the derived output errors. This activity builds upon prior federation results validation and provides an additional opportunity to assess the validity of the federation's output.

This activity assumes that some personnel from the VV&A Team continue to be involved in the federation execution and use in the later steps of the FEDEP and that the validation techniques selected for this activity conform to the V&V Plan.

7.6.3.1 *Information Required*

- Federation Development and Execution Plan
- Verified derived federation output
- Verified Federation Agreements
- Documentation of execution problems
- Federation Acceptability Criteria

- Federation Referent
- Federation acceptance/accreditation recommendations

7.6.3.2 Functions (Tasks)

- Evaluate the completeness of the derived federation output against the Federation Acceptability Criteria and Federation Referent and identify areas of incompleteness
- Estimate the error characteristics of the derived federation output
- Evaluate the correctness of the derived federation output against the Federation Acceptability Criteria and Federation Referent and identify areas of incorrectness
- Estimate the uncertainties associated with the errors in the derived federation output
- Identify any observed representational anomalies and infer their probable causes
- Document the results of validating the derived federation output

7.6.3.3 Information Produced

- Federation output validation results
 - Within the context of the Federation Referent, identification of the Federation Acceptability Criteria that the derived federation output
 - Meets
 - Does not meet
- Characterization of the representational errors in the derived federation output that exceed the Federation Acceptability Criteria limits
- Estimates of the uncertainties of the representational errors in the derived federation output
- Observed representational anomalies and their probable causes

7.7 Phase 7 – Consolidate Federation VV&A Products

This phase of the overlay focuses upon documentation and reuse to improve the productivity and efficiency of future federation VV&A processes. In support of this goal the VV&A Team collects from the preceding VV&A efforts and assembles them into a consolidated package. This package will include the final Federation Accreditation Plan, Federation Referent description, final Federation Acceptability Criteria, final Federation V&V Plan, federation scenario verification results, federation conceptual model V&V results, federation requirements verification results, federation design verification results, FOM verification results, federation agreement verification results, federate V&V results, federation infrastructure verification results, federation data set V&V results, integrated federation V&V results, federation output V&V results, and VV&A lessons learned. This phase also supports the data analysis efforts defined in the FEDEP as needed.

Figure A1-10 illustrates the key activities in this phase of the VV&A overlay. The subsections that follow describe each of these activities.)

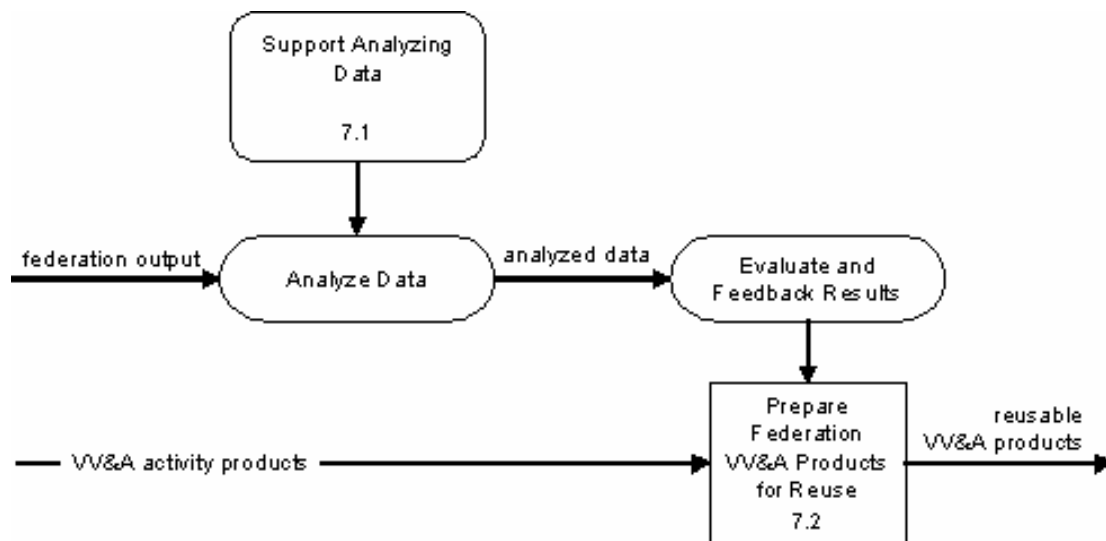


Figure A1-10: Consolidate Federation VV&A Products (Phase 7) Activity Diagram.

7.7.1 Activity 7.1 – Support Analyzing Data

This activity supports analyzing the federation output. During this activity, the VV&A Team collects, assembles, and documents the V&V evidence from all of the previous activities. They also complete documenting the traceability between the analyzed data and derived output.

The VV&A documentation should include the collected evidence and its relation to the Federation Acceptability Criteria. An important aim is to make this documentation easily understood by User/Sponsor and to prepare it in an appropriate format as specified in the V&V Plan. Further, this documentation should describe the conditions of recommended use, rational for those recommendations, possible corrective actions for follow-on federation executions, and the VV&A lessons learned.

7.7.1.1 Information Required

- Federation V&V results documentation
- Federation Referent
- Federation Acceptability Criteria

7.7.1.2 Functions (Tasks)

- Collect, assemble, and document the verification and validation results from prior activities
- Contribute to documenting the traceability between the analyzed data and the derived output
- Develop and document the conditions of recommended use (i.e., accreditation recommendations where needed)
- Develop recommendations for improving the VV&A activities from the lessons learned

7.7.1.3 Information Produced

- Integrated federation V&V results documentation
- Information describing the traceability between the analyzed data and the derived output
- Federation acceptance/accreditation recommendations
- VV&A lessons learned
- Recommendations for VV&A activity improvements

7.7.2 Activity 7.2 – Prepare Federation VV&A Products for Reuse

This activity prepares the federation products for reuse to improve the productivity and efficiency of future federation development and execution processes. The VV&A activity focuses upon storing all reusable federation products (including both FEDEP and VV&A products) in an appropriate archive for general reuse within the domain or broader distributed simulation community.

The VV&A Team should gather all of the information that could be re-used and store that in an accessible form in an accessible place. This includes archiving the FOM, any modifications to the SOMs of federates, and other federation products that may also be reusable, such as the Federation Scenarios and the Federation Conceptual Model. In fact, capturing the full set of federation products required to reproduce the federation execution may be advantageous in some instances. All VV&A documents including the Federation Acceptability Criteria, Accreditation Plan, V&V Plan, V&V results and acceptance/accreditation recommendations should be included in the archive. These products contribute to establishing the credibility of the federation as well as the federation's results. The VV&A Team should consolidate the products from the federation VV&A processes and ensure that these products conform to the relevant re-use exchange criteria, formats, and available standards. They should then integrate the VV&A archive products with those produced by the Federation Development Team and archived according to the federation re-use plan if there is one.

The Federation Development Team should determine which federation products have potential for reuse in future applications whereas the VV&A Team should endeavor to capture all products stemming from their VV&A activity.

7.7.2.1 Information Required

- Products of the FEDEP and VV&A processes
- Guidance for judging the acceptance of products as reusable

7.7.2.2 Functions (Tasks)

- Consolidate the products produced by the federation VV&A processes
- Ensure that the VV&A products have been archived according to the federation re-use plan
- Ensure that these products conform to the relevant re-use exchange criteria, formats, and available standards
- Confirm that the FEDEP products relevant to future VV&A activities have been archived according to the federation re-use plan

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7.7.2.3 *Information Produced*

- Reusable consolidated federation VV&A products package

8.0 CONCLUSION

This recommended practice has provided a detailed view of the VV&A overlay to the FEDEP. Currently, this model represents the best practices available to the VV&A community. The VV&A overlay is a tailorable process and is offered as “hands-on” implementation-level guidance to VV&A practitioners.

REPORT DOCUMENTATION PAGE																					
1. Recipient's Reference	2. Originator's References	3. Further Reference	4. Security Classification of Document																		
	RTO-TR-MSG-019 AC/323(MSG-019)TP/13	ISBN 978-92-837-0088-3	UNCLASSIFIED/ UNLIMITED																		
5. Originator	Research and Technology Organisation North Atlantic Treaty Organisation BP 25, F-92201 Neuilly-sur-Seine Cedex, France																				
6. Title	Verification, Validation, and Accreditation (VV&A) of Federations																				
7. Presented at/Sponsored by	Final Report of Modelling and Simulation Group 019 / Task Group 016.																				
8. Author(s)/Editor(s)	Multiple		9. Date April 2008																		
10. Author's/Editor's Address	Multiple		11. Pages 104																		
12. Distribution Statement	There are no restrictions on the distribution of this document. Information about the availability of this and other RTO unclassified publications is given on the back cover.																				
13. Keywords/Descriptors	<table border="0"> <tr> <td>DIS (Distributed Interactive Simulation)</td> <td>Military applications</td> <td>Resources</td> </tr> <tr> <td>Distributed systems</td> <td>Military planning</td> <td>Simulation</td> </tr> <tr> <td>HLA (High Level Architecture)</td> <td>Models</td> <td>Specifications</td> </tr> <tr> <td>Integrated systems</td> <td>Quality assurance</td> <td>Standardization</td> </tr> <tr> <td>Interoperability</td> <td>Requirements</td> <td>VV&A (Verification, Validation and Acquisition)</td> </tr> <tr> <td>M&S (Modelling and Simulation)</td> <td>Research management</td> <td></td> </tr> </table>			DIS (Distributed Interactive Simulation)	Military applications	Resources	Distributed systems	Military planning	Simulation	HLA (High Level Architecture)	Models	Specifications	Integrated systems	Quality assurance	Standardization	Interoperability	Requirements	VV&A (Verification, Validation and Acquisition)	M&S (Modelling and Simulation)	Research management	
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14. Abstract	<p>This document defines the recommended processes and procedures that should be followed to implement Verification, Validation, and Accreditation (VV&A) for federations being developed using the High Level Architecture (HLA) Federation Development and Execution Process (FEDEP). The VV&A overlay described in this document is a tailorable process that overlays the FEDEP and is intended to apply across a wide range of functional applications. This overlay identifies and describes the recommended VV&A processes that should be followed to assure the acceptability and utility of federations for particular intended uses. The overlay also identifies and describes the information feeding and resulting from those processes as well as the relationships between the FEDEP and the VV&A processes and their respective information products. In addition, this overlay defines those terms uniquely needed to characterize the FEDEP VV&A overlay.</p>																				





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